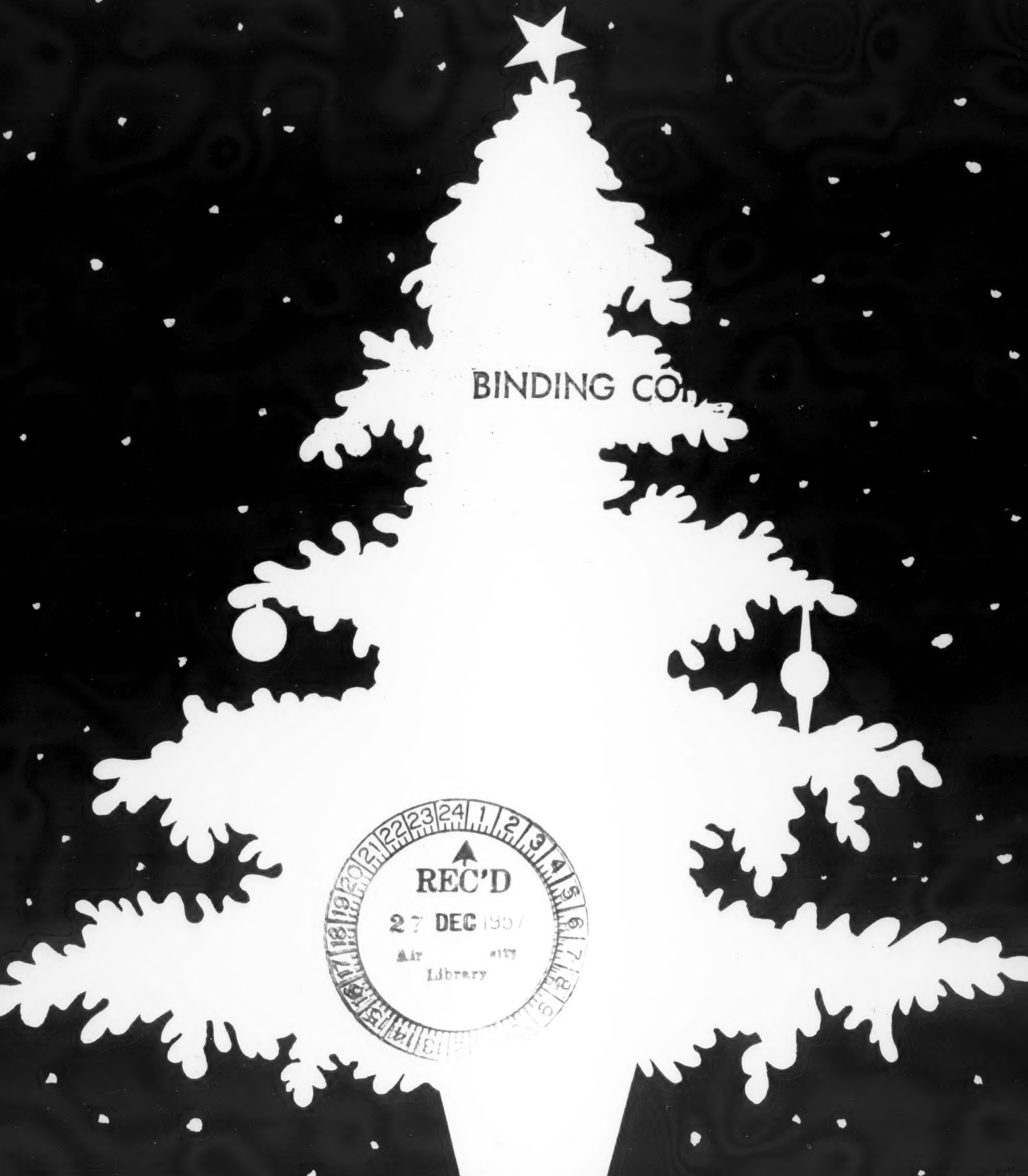
SIGNAL

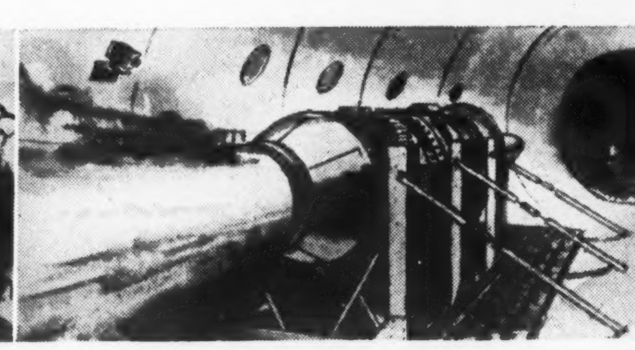
December 1957



Christmas Wishes from AFCEA

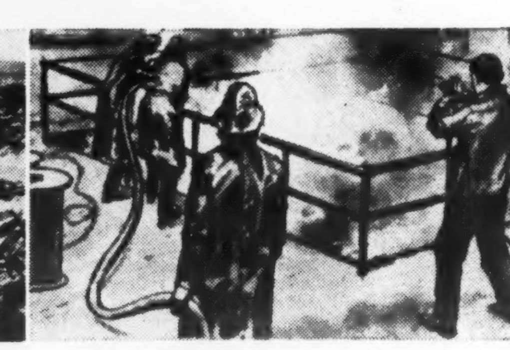
MIRACLE IN MINIATURE

Observation and control of amphibious and airborne landings.



Close observation of jet or piston engine test performance.

Surveillance of assembly areas and movements of forces.



Observation of danger areas, where exposure would involve danger to personnel.

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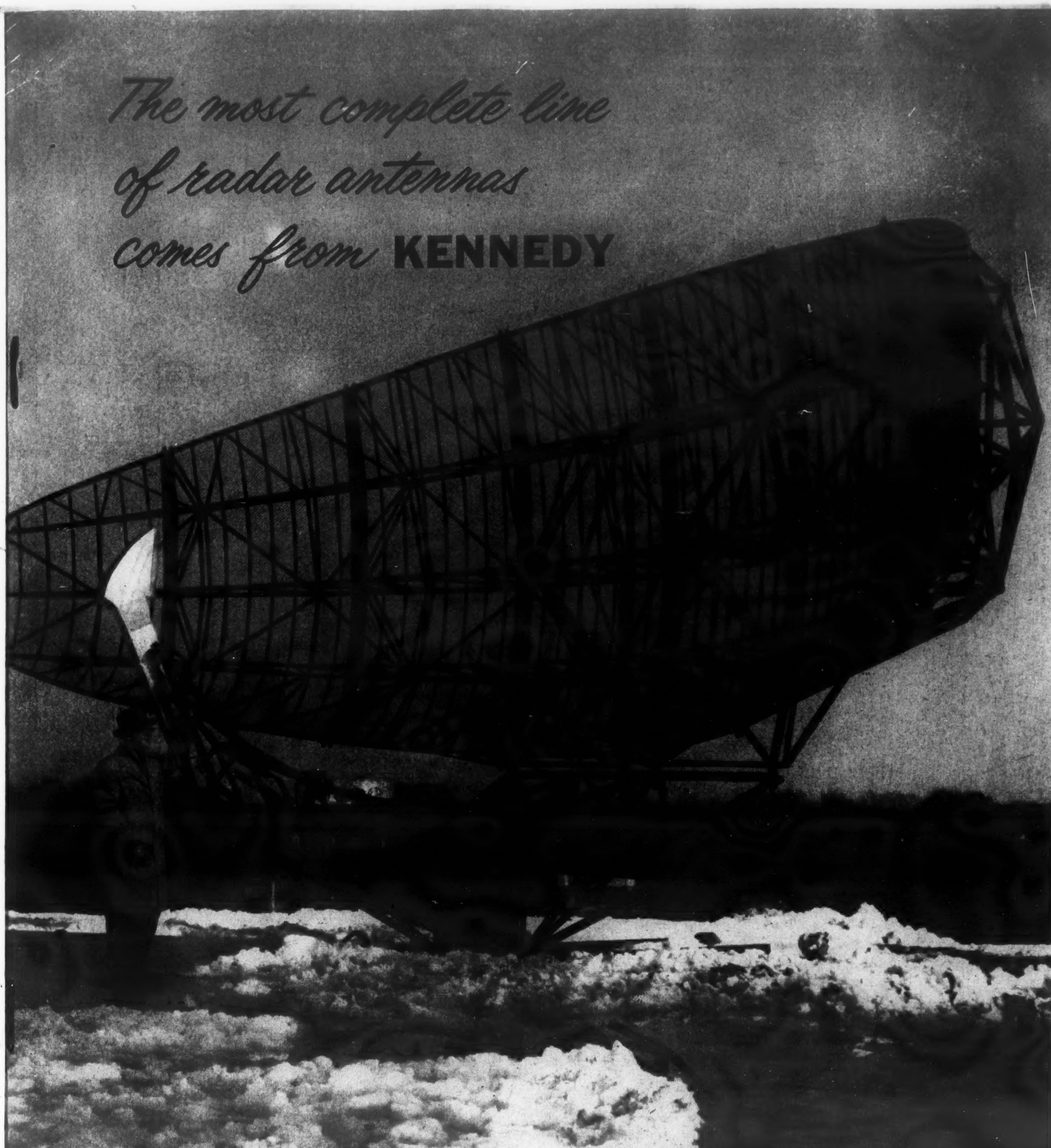

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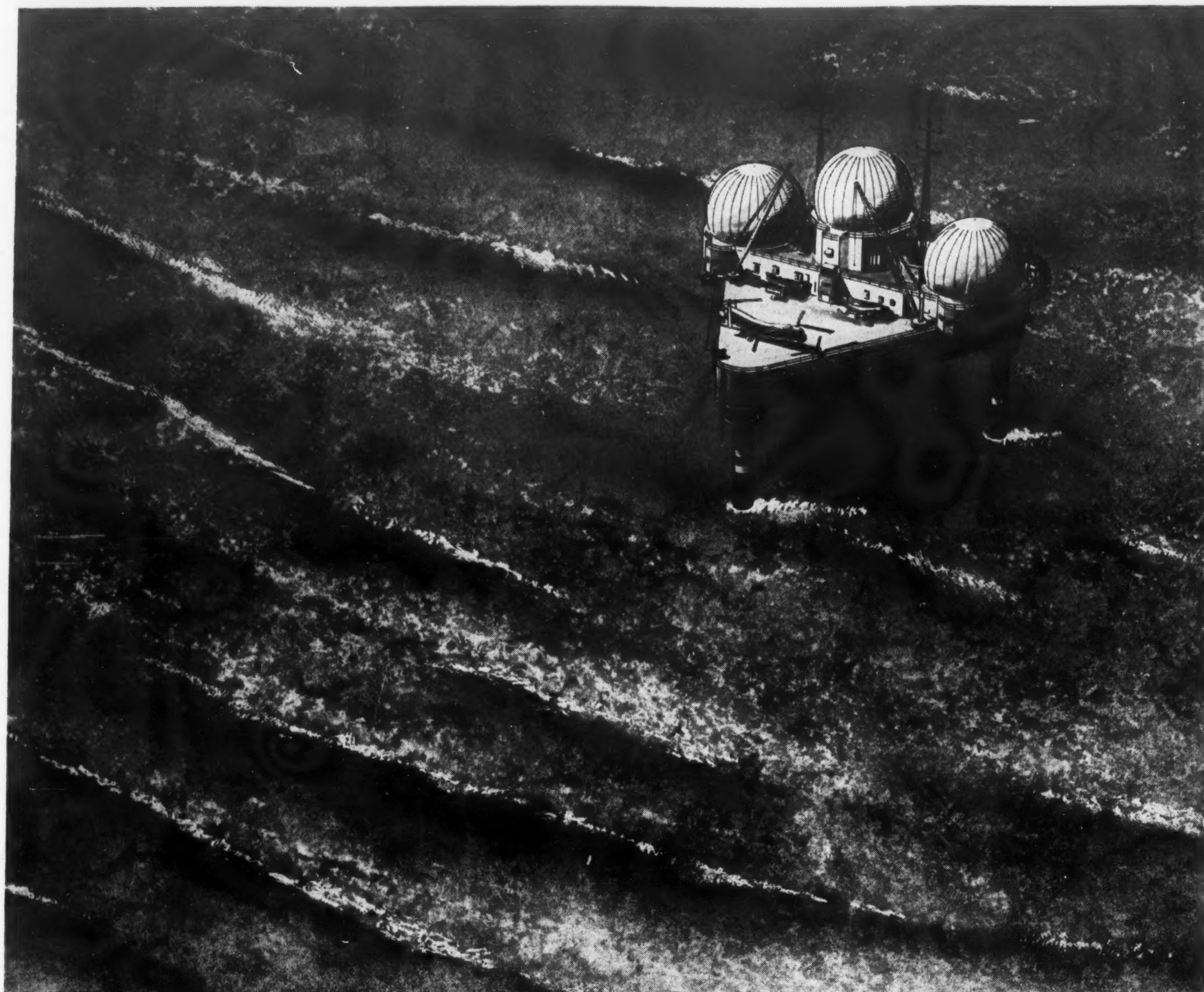

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Washington 6, D. C.
Phone: EXecutive 3-3033

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EPA

SIGNAL

Communications-Electronics-Photography

Journal of the Armed Forces Communications and Electronics Association

VOLUME XII **DECEMBER 1957** **NUMBER 4**

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COVER

SIGNAL's cover represents Christmas Greetings from the Directors, Officers, the Executive Committee and Headquarters of the Armed Forces Communications and Electronics Association.

For the outstanding contributions of our authors and for the continuing support and services of our advertising representative and the advertisers in SIGNAL; for the complete cooperation of our printer, engraver, artist, members and friends, the editorial staff of SIGNAL is profoundly grateful and wishes to add its sincere holiday greetings.

Technology and the Air Force ballistic missile Program

I AM GOING TO SAY a word about the following: economy in Government; electronics in today's and tomorrow's military, and the Air Force Ballistic Missile Program.

Perhaps, uppermost in your minds today is economy in Government and how it affects you. For quite a number of months, the press has contained statements concerning more conservative economics in Government, particularly in the matters of military spending and procurement. More recently, a number of public speeches by persons in policy making positions have confirmed that governmental economy has become the order of the day and of the immediately foreseeable future. Quite obviously, those of us who are planning and executing military development programs are affected. Some problems will certainly arise which will be difficult to solve at the moment. A contracting operation is certainly a greater managerial challenge than an expanding one. On the other hand, I see no need for pessimism. There are certain advantages in careful, conservative management. A survey conducted to determine the relative success of various classes of recent years from one of our most famous universities came up with the finding that the depression borne class of 1931 had the largest average earnings. Intelligent thought can sometimes reverse difficult situations and turn them to the advantage of those willing to meet the challenge.

The situation regarding development and procurement for the Armed Forces would have been somewhat uneasy, even though the recent economic policies had never occurred. This is true because advances in science and technology have profoundly affected military planning since World War II. I refer to the general use of nuclear and thermonuclear weapons and to the very great increases in the speed of aircraft and missile delivery systems. The result has been a retreat from the concepts of great masses of aircraft and surface vessels which characterized World War II. The impact upon those engaged in producing aircraft is obvious.

At first glance, it might appear that the market for electronic devices might be sharply reduced since the number of aircraft required to do a given task has been decreasing as the performance of weapons increased. However, due to the need for better navigation and control devices in high performance aircraft, the electronic devices have become more sophisticated, partially compensating for the reduction in numbers. Furthermore, the environment of the high performance vehicles is increasingly more difficult for air crews; therefore, they require more and more assitance from electronic, electrical and mechanical devices. This trend, of course, is carried to an extreme in guided missiles where black boxes eliminate the pilot. Consequently, in the air-nuclear age, the demands upon the electronics industry have become greater than ever.

I believe that at this point it is important to emphasize that there is now and probably always will be a demand for manned aircraft for military purposes. The performance of manned aircraft is increasing at a rate which keeps them competitive with missiles. The transition to missiles is just beginning and will continue in a slow, orderly manner as missiles prove their reliability. Consequently, organizations interested in serving the cause of military electronics must keep one foot firmly planted in the technology already established, but be prepared with the other to step into the imaginative and challenging missile electronics field.

Although most crystal balls are cloudy at best, it appears that the best advice for those interested in staying in or entering the military electronics field is sound planning and diversification. A policy of exploiting present techniques, but exploring advanced and new fundamental approaches, seems necessary. Sound judgment and good management are more essential than ever before. The low cost producer of quality goods will get plenty of business.

From the Air Force standpoint, more, rather than less, thought must be given to weapons systems before they are begun. The studies must be done in an extremely careful and competent manner. Systems engineering has become increasingly important. So from industry's standpoint, each organization participating in a military program must have people capable of understanding and matching the interface with other participants. Someone must review the entire result and see that it fits together. The fundamental results of research groups must be extracted and fed into the systems engineers to avoid entry into costly blind alleys.

The work of the fundamental research groups themselves, or more precisely, their efforts which are supported by military funds, must be planned more carefully, with less

by Major General Bernard A. Schriever, USAF / Commanding General / Air Force Ballistic Missile Division / Air Research and Development Command

duplication. I do not wish to imply that investigations of a general scientific nature should be curtailed, but that such work will probably be supported to a larger degree by organizations with a specific charter for such work.

Perhaps some of you might be interested in a few of the specific areas in electronics which some of my staff believe are particularly worthy of attention for future Air Force applications. I might mention continued emphasis on solid-state devices, particularly with regard to quality control in manufacture and to reliability in application. Improved and more accurate instrumentation for missile flights, improved packaging for high static and vibration environment, and light weight electronics associated with gyros and inertial systems are needed also. Further work on data extraction devices, and the work of those whose purpose is to convert information from analog to digital form, would be worthwhile. Since the interest in mouse traps has begun to wane, the world would probably beat a path to the door of someone who built a really outstanding accelerometer—most particularly if he could do it for a reasonable price.

Now, I would like to say a little about the Air Force Ballistic Missile Program.

The long-range ballistic missile program of the United States Air Force represents the largest integrated technical development program ever attempted by this country. It involves a simultaneous extension in practically every phase of the guided missile art. Compared with previous developments, it includes higher thrusts, higher weight-to-structure ratios, higher speeds, higher accuracy and greater versatility in guidance and control, higher rates of burning of propellants, higher temperatures, and greater expansion of facilities and industry capability in a short period of time.

Management and Organization

There are two somewhat separable aspects of our ballistic missile program in which the relationship with previous projects appears worth mentioning. One aspect has to do with management and organization. The other concerns general technical aspects and testing.

First, let me discuss organization and management. From the beginning of the accelerated program, it was evident that questions of managerial, philosophical and organizational approach would need special attention. Why was this? Well, first, it was obvious that the total effort, if carried out successfully in a relatively short time, would involve a considerable fraction of the nation's scientific and material resources. Second, the simultaneous advances required for the present program in all aspects of guided missile system art made clear that large facility, hardware, and reliability testing programs would be needed. Third, it was obvious that the entire program would have to be widepread geographically and would have to include contributions by large numbers of organizations. Therefore, the entire effort would have to be unusually well organized and highly supported on a good management and good scientific base. These operations could not be left to trial and error and hit-or-miss experimentation.

Top military and technical people have joined to create and maintain a research and development plan, a production plan and an operational plan with the least doubts as to the fundamental soundness and proper timing for each step. Of course, any program comprising a vast number of interrelated steps cannot be precisely laid out ahead of time. Moreover, some steps must depend upon progress or data obtained in earlier ones. But the objective has been to plan a program that will have a minimum chance of hinging upon any greatly speculative technical issue, and, equally important, upon any questionable evaluation as to the ability to perform the development and production as required, or to train the people and establish the operational bases on time.

A web of communications has been set up, converging into one central source competent to evaluate the information and to provide proper direction to all the team members. Even the initial relationship between military requirements and the performance specifications requires regular reviews, and modifications to attain an earlier result always have to be weighed against a competitive method gaining a later but superior result. Planning, monitoring and optimum assignment of facilities is a major effort for the central management organization. Morevover, in view of the plan to parallel the research and development with production planning and complete operational implementation, a large amount of the central management's internal activities have to do with interactions among the technical, operational and procurement aspects.

Technical Aspects

Now leaving management, let me say a few words about the technical aspects of our program—first, with regard to previous Air Force development programs. Roughly speaking, the counterpart, in the sense of a previous technical step, can generally be found spread over the entire guided missile, aircraft and electronics art. Thus, a ground radar that had nothing to do with guided missiles in the past has furnished a basis for an extension for some of the ICBM system. Something similar can be said with regard to the ground computers. Some of the techniques and components came out of aircraft, others out of short-range ballistic missiles, and still others from surface-to-air and even air-to-air missiles.

In making the major technical decisions, a notable effort was made to bring in the experience of all of the leaders of the guided missile and associated art. As an example, for the testing plan, experts from earlier programs either joined the present one or were brought into the key discussions. Some believed that the best way to move rapidly was to analyze every test completed and to use all

the results to make improvements before attempting a next test. Others argued that without a set of tests that would provide statistical and confirming evidence of faults, no solid progress could be made. Many had experienced their worst problems in the past when they tried to reproduce results and wanted special emphasis on catering to the fabrication and assembly problems from the outset. Others felt substantial redesign could be tolerated. Judgment as to technical risk in skipping steps to save time varied, of course, but we had the assistance of most of the experts and the facts of the past. All of these past experiences naturally had to be interpreted in the light of our own specific problems. We finally decided on a test philosophy which carefully considered the transition to production and the attainment of reliability.

A single or a few shots of a missile, built breadboard fashion by its inventors in a closely supervised model shop, may be a satisfactory approach to illustrate a principle. However, in our guided missile development, the step being taken from the technical standpoint is essentially beyond question as to its scientific basis. The key problem is to so organize the program as to assure the efficient working out of all of the engineering details (some by theory and some by experiment), the attainment of reliability through a great deal of testing, and an industrial capability to reproduce the results in the quantities required for a military force.

Therefore, we have held uppermost in our planning that production and operational capability are the real end goals of the development.

Reliability

Now a word about reliability. In the past, reliability considerations have not been in the foreground often enough. Clearly, a complete guided missile system cannot be very useful in a national emergency if it is likely to fail in some important respect more than a small fraction of the time. But the complete system consists of many major subsystems, including of course much more than the flying vehicle itself. Suppose we ask for a modest 50 per cent chance that the complete system trial will occur without a malfunction of some major subsystem such as the power plant, the structure, the guidance subsystem or the ground equipment. For simplicity, suppose there are five or six of these main subsystem elements. Then, to have a 50 per cent chance for a completely successful flight, each of these subsystems must be counted on for roughly a 90 per cent chance of operating perfectly. But each of these subsystems itself consists of hundreds of critical components, which must then have an average reliability during flight in the 99.9 per cent region, with a failure of only one in a thousand. Even if each of these components is laboratory tested, improved and retested innumerable times, this must be followed by systems testing to determine the interactions of one component on another when working together. And then, finally, a flight test will expose the possible reduced reliability owing to the environment and unknowns in the actual flight that no prior simulation or analysis can dependably reveal.

Typically, flights of guided missiles are measured in minutes. A flight test program, especially in its earlier stages, reveals only fragments of data for various parts of the complete trajectory. Hundreds of flights may be needed to accumulate a single hour of operating experience. It is apparent that the attainment and the proof of reliability cannot rely alone on flight test, because of the enormous expense and the relatively small amount of data obtained. Wherever possible, all subsystems must be brought to a high reliability by testing on the ground.

This does not mean that the first flight test should be delayed until testing on the ground has caused all elements to reach a stage of reliability where nothing remains but the final interactions in the operating environment. Flight testing in its initial stages obviously is carried out, not for the purpose of exhibitions, but to uncover interaction and flight environmental problems as early as possible, even with the virtual certainty that the first flight tests will be handicapped by unreliability of components. Thus, the final "ground" development of all subsystems and components for the goal of a successful operational flight depends partially on the results of earlier imperfect flights. Complete systems tests, including missile launchings, constitute the only way ultimately to completely confirm the soundness of the system design.

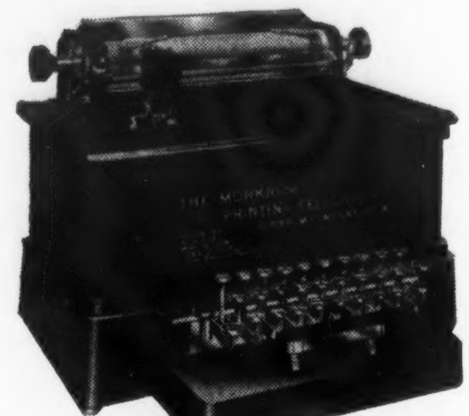
Another factor in achieving reliability is hardware requirements. Programs of the past have generally lacked sufficient hardware to make possible any satisfactory approach toward reliability testing. Planning the amount of hardware for each stage of the program, from the begining of component development and reliability check-out through to final systems testing and initial operational capability for military use, is a major factor in setting up a good missile development program. We think we have this in hand.

Another vital ingredient is facilities. There is probably no characteristic of major weapon systems programs that has so often in the past been the determining factor in the speed and efficiency of development than the facilities program. The tendency all too often is to fail to include the needed facilities, or to underestimate the lead time required and the technical difficulties of such facilities programs. Major facilities acquisition also involves difficult arrangement-making problems between various government agencies and between such agencies and industrial contractors. Recognition of the size, scope, and complexity of facilities problems is a prime requirement for the successful execution of a major weapon systems program.

Summarization

In summary, I wish to emphasize the key elements of thought contained in my previous statements. These concern the general orientation of policy and planning which I recommend to firms or groups interested in contributing to that portion of national defense connected with modern weapons such as ballistic missiles and supersonic aircraft. These contribute to careful planning with emphasis upon over-all weapon systems rather than upon specialized functions of the "ivory tower" type. The elements themselves are: carefully directed fundamental research; teamwork as expressed by ability to see over boundaries and comprehend problems in other areas such as aerodynamics, propulsion, etc.; sound management and economics, plus imagination.

A small but well informed and highly imaginative planning group in each case can assist in "crystal ball gazing" to tie together such seemingly diverse elements as economic, over-all military policy, tactical usage, training, production and maximum use of the most advanced technology the state of the art allows. I also hope that my few observations on the ballistic missile program have been informative.



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1957 Golden Anniversary Year

central RADIO PROPAGATION laboratory

by Dr. Frederick H. Brown, Director, Boulder Labs.

THREE YEARS AGO, THE National Bureau of Standards (NBS) opened a new multi-million dollar radio research center in Boulder, Colorado, next door to the University of Colorado. Located at the foot of the Rockies, this western laboratory is in an uncongested area ideal for radio propagation experiments. Here the climate allows year-round field work, and the varied terrain makes it possible to study the effects of many different land formations on the propagation of radio waves.

A primary impetus for establishing the new laboratory was the growing need for accurate information on the characteristics of radio waves over a wide range of frequencies and under many diverse conditions. The remarkable technological developments of recent years have greatly expanded the frequency spectrum available for communications, so that equipments now function at frequencies up to 100,000 megacycles. At the same time, the available radio space has been increasingly utilized by commerce, industry, science and the Armed Services. Radio propagation data has thus become of vital importance in such fields as global aviation, all-weather shipping and harbor control, frequency allocations and world-wide communications.

The NBS radio research center at Boulder consists of two laboratories — the Central Radio Propagation Laboratory (CRPL) and the Radio Standards Laboratory (which provides standards for electric quantities at radio and microwave frequencies).

CRPL originated in the Interservice Radio Propagation Laboratory, which the Combined Chiefs of Staff (U. S. Armed Forces) established at NBS in the spring of 1942. During World War II, this laboratory provided the Armed Services with valuable information on radio propagation conditions. Now CRPL has primary responsibility within the nation for collecting, analyzing and disseminating data and information on radio propagation. To carry out this responsibility, the laboratory at Boulder conducts research on the fundamental nature of radio waves, the basic theories of radio-wave propagation and the characteristics of radio energy under widely varying conditions. It operates a network of field stations from the arctic to the tropics, and exchanges data with other radio research laboratories throughout the world. Within the Central Radio Propagation Laboratory are two divisions—Radio Propagation Physics and Radio Propagation Engineering.

The Radio Propagation Physics program involves studies of radio-wave propagation over long distances via the ionized regions of the earth's outer atmosphere, which are known collectively as the ionosphere. The program includes: (1) basic research on upper atmosphere physics, on the formation and disturbances of the ionosphere and on the interaction of radio waves with the ionization; (2) study of the characteristics of specific propagation mechanisms such as ionospheric reflection, ionospheric scattering and guided mode propagation, and (3) regular service as in the prediction of long-term changes in useful frequencies for communication, in the warning of short-term disturbances to communication and in the collection and distribution of ionospheric and solar data on a national and international basis.

One phenomenon of the upper atmosphere being studied in the radio physics division is airglow, a faint illumination normally not visible to the naked eye but always present at a height of about 60 miles. It is caused by radiation from atoms and molecules excited by solar energy.

To measure airglow, the Bureau developed a telescopic photometer which has improved spectral resolution and gives a more rapid sky coverage than was hitherto available. It is arranged to scan the sky repeatedly and automatically and to record the observed intensity within narrow spectral bands. Filters exclude background radiation from space and allow only the airglow colors to be recorded—red and green emitted by oxygen atoms, yellow emitted by sodium atoms and infra-red emitted by OH radicals. The incoming radiation is translated into an electric current by a photoelectric cell. The current is amplified and then recorded through an inked pen attached to a recording galvanometer. Analysis of the records has been accelerated by the use of punched-card and electronic-computer techniques.

By correlating airglow data gathered from a network of field stations with other kinds of upper atmosphere studies, CRPL hopes to gain more definite information about the composition, temperature and behavior

of the ionosphere. Some of the other studies include theoretical investigations and instrumental observations of the complex motions which the ionosphere undergoes as a result of solar heating and lunar and solar gravitational tidal forces.

At many radio sounding stations throughout the world, detailed observations of the ionosphere are made with specially designed instruments. At the present time, 22 of these stations are being operated either by the Boulder Laboratories or by other Federal agencies, foreign governments and universities working in cooperation with the Boulder Laboratories. Several of these stations have been established to participate in the International Geophysical Year.

Much information is being gathered on the height and density of the layers of the ionosphere through vertical incidence methods. With an ionosonde, radio pulses of various frequencies are beamed at the ionized layers and the time interval between the emitted signal and its echo is measured.

Predictions of maximum usable frequency are usually based on ionosonde data. However, it has been discovered that communication often takes place at frequencies somewhat higher than indicated by existing theory based on vertical incidence studies. This type of communication apparently occurs when some of the higher frequency radio waves strike the ionosphere and reflect obliquely over long distances. So, oblique incidence is now being studied in relation to the vertical incidence.

In the Arctic, the Boulder Laboratories are investigating the intensity of radio waves propagated via the ionosphere in the region near the visual auroral zone, where radio waves tend to be absorbed instead of reflected. Information on this phenomenon is essential if reliable radio communication paths are to be maintained from points in the United States to Europe and Asia.

Ionospheric Scattering

By means of a very long antenna suspended across a nearby canyon, NBS scientists are transmitting low frequency signals directly upward to the ionosphere and studying the different modes of reflection present uniquely at low frequencies.

Since 1951, the Bureau has pioneered in the study and use of a mechanism of radio propagation via the ionosphere called "regular ionospheric scattering." By this mechanism, radio energy is scattered when it strikes irregularities in the ionosphere. These signals are remarkably dependable, actually tending to be enhanced at times when ionospheric disturbances completely disrupt regular radio communications.

The study of ionospheric scattering requires specialized receiving equipment, a powerful transmitter and large antennas. Experimental installations have been set up over paths within the United States and in Alaska, between Newfoundland and the Azores, and elsewhere in the Northern Hemisphere. From experiments conducted at these locations, NBS has found that scatter effects vary with latitude. For instance, the median power transmitted over a standard path in arctic and sub-arctic latitudes is about ten times stronger than that propagated over a similar path at temperate latitudes. The signal also varies with time of day and year.

The Boulder Laboratories now is extending its research program to study ionospheric scatter in a geographical area where the mid-point of the path will be nearly at the geomagnetic equator. As part of this research, seven stations have been set up in South America in conjunction with the International Geophysical Year program.

Research in this field is expected to provide information on heights at which scattering occurs, dependence of signal-strength on the transmission frequency and the scattering angle, relative contributions to the scatter signal from meteoric ionization and atmospheric ionization due to solar radiation, and effect of the earth's magnetic field on scattering.

Investigation of ionospheric scatter has led to an increased emphasis on antenna research which has now become an important part of the NBS program. The work on very-high-gain antennas has become particularly important in connection with ionospheric scatter communication.

A challenging study is also being made of Sporadic-E. Sporadic-E reflections are apparently the result of electron or ion clouds in the E layer of the ionosphere. These clouds are of varying sizes and drift through space so that the phenomenon seems to come and go. In certain latitudes, it seems to be related to scattering and in others its seems to result from a combination of factors including reflection. Sporadic-E is responsible, for instance, for low-band television signals being sporadically transmitted over amazingly long distances. In particular, scientists wish to know the frequency dependence, the association of vertical-incidence Sporadic-E with that seen on the oblique incidence paths, and the association of Sporadic-E with regular ionospheric scatter.

In the field of radio astronomy, much is learned about the earth's ionosphere by observing how it affects radio-star energy which passes through it. Also, by studying radio emissions from the planet Jupiter, information is gathered on this planet's ionosphere which by comparison can lead to a more precise knowledge about the earth's ionized upper atmosphere.

Action of solar- and cosmic-radio waves is observed daily with radio telescopes, and from an analysis of automatically recorded data comes information of benefit to the radio prediction services as well as to the basic study of the sun.

Also under study are the tremendously long paths traced by whistlers — radio energy that originates from lightning discharges penetrates the lower ionized layers and follows the earth's magnetic lines of force at heights up to 25,000 miles to arrive in the opposite hemisphere.

When better understood, whistlers may provide means of gathering some kinds of information on space nearly 100 times farther away from earth than the IGY satellite will travel. *It is conceivable that the whistler path may some day be used for direct communication between two points in opposite hemispheres.*

Prediction Services

During the years since it was established, the NBS service of issuing radio propagation predictions three months in advance has proved invaluable to radio equipment manufacturers and to communication agencies for frequency allocation and efficient frequency usage.

Of great benefits also have been the short-term forecasts of possible disturbances in the ionosphere which might affect communication. To gather this information, the Bureau cooperates closely with solar observatories throughout the world.

The Radio Propagation Engineering Laboratory is largely concerned with studying the characteristics of radio waves propagated through the troposphere and with the meteorological and other conditions that affect such propagation. It also conducts applied research on radio-wave

(*Continued on page 12*)

propagation as it affects the design of radio systems, and places much emphasis on propagation characteristics that limit radio's effective distance range, the rate of radio transmission of intelligence, and accuracy of direction-finding and navigation systems. Recent research has shown that VHF and UHF signals often travel beyond the line-of-sight radio horizon. This is due to a phenomenon known as a tropospheric forward scatter. Theories now being developed indicate that, in this style of scatter, the radio energy is reflected over long distances by small irregularities in the atmosphere caused by turbulence.

Detailed studies are under way on long-distance tropospheric propagation and ultra-high-frequency communication to learn how they are affected by weather, terrain, antenna gain, space and frequency diversity, signal fading and the variation of polarization and phase due to propagation conditions. In addition, experimental studies of variations in propagation velocity over the line-of-sight transmission paths use techniques developed to measure these variations at 1,000 to 10,000 Mc with an accuracy, during five-minute sampling periods, of a few parts per billion.

Atmospheric Turbulence

Since atmospheric turbulence is associated with meteorological conditions, radio measurements were made over ten-mile lengths of atmosphere under various conditions of cloud formation, barometric pressure, air temperature, relative humidity, wind velocity and solar radiations. From an analysis of the data, information can be derived about the physical nature of atmospheric turbulence that is valuable to designers of direction-finding equipment. Results of these studies have led to an estimated immediate saving of approximately $50,000,000 to the United States Government in application to radio systems.

In another approach to the problem of atmospheric turbulence, detailed measurements have been made of variations in velocity of radio waves propagated through very small samples of the atmosphere — *over paths no longer than an inch.*

Both military and commercial users of radio need predictions of the external noise level arising from man-made, atmospheric and galactic radio noise. They also need to know the character of the noise to evaluate its effect on any given system. An atmospheric radio noise recorder, developed by the Bureau and accepted internationally for use in a world-wide measurement program, provides continuous recordings of the average noise power received on a standard antenna at eight discrete frequencies in a range from 15 kc per second to 20 Mc per second. Some of these recorders have been modified to record also the average noise voltage and the average of the logarithm of the noise voltage. It has been shown that these three statistical characteristics of the noise provide a reasonably comprehensive picture of the physical nature of its amplitude distribution.

Theoretical Investigation

Several theoretical investigations are being carried out on very low frequency propagation. To interpret electromagnetic radiation from lightning discharges and other high intensity transient sources, for instance, calculations have been made that indicate that the waveform of the radiation field is modified by diffraction and loss in the finitely conducting ground. Also investigated has been the theory of the propagation of very low frequencies over moderate and great distances via the ionosphere.

Aiming at more reliable world-wide communication, the Bureau is seeking to improve the efficiency of very-low-frequency (VLF) communications circuits from 10 to 15 kc. Since antennas for radiating VLF energy are usually very large and inefficient, a basic study of design limitations of such antennas is now in progress.

Use of flush-mounted antennas is now common in jet aircraft and guided missiles. An anaysis has been made, therefore, of the effect of covering the slot with a layer of fabric or other dielectric. In the case of the slotted cylinder antenna, this dielectric coating can improve the omni-directional characteristics which are desirable for beacon applications.

To make optimum use of the radio spectrum, it is necessary to have not only information on noise and interference charactertistics but also on those characteristics of the carrier wave that can be modulated to transmit a message, and on characteristics of systems that modulate or demodulate carrier waves.

The Bureau has designed and constructed equipment to measure carrier characteristics under a wide variety of conditions. Initial tests are now being made on HF ionospheric fading and forward scatter tropospheric fading carriers. Results of these and other investigations will be used by Bureau engineers to increase the accuracy of predicting radio systems performance under numerous typically encountered conditions.

For several years now, the Bureau has been investigating precision-navigation systems that use low radio frequencies. Long-range sky wave reflection of signals from experimental navigation-type transmitters were transmitted from eastern United States to Central and South America. The signals were found to have a very high phase stability, indicating the feasibility of a navigation system utilizing long-range skywaves.

The Bureau has been investigating special theories pertinent to the phase computation of the low frequency ground waves and applying the results to radio navigation systems operating in the range 10 kc to 1 Mc for earth conductivities ranging from zero to infinity. The vertical-lapse effect on the refractivity of the earth's atmosphere has also been evaluated for various meteorological conditions and for the altitudinal effect of the above-ground receiver. Although this work is applied directly to navigation systems, it is primarily basic research in radio propagation.

Although the phase and amplitude of ground waves over complex propagation paths cannot be treated theorectically, instrumentation for the exact measurement of these quantities over any propagation path up to approximately 100 miles has been developed. This involved a measuring system with advance-type circuits and automation of all data recording. Such a measurement system is essential in confirming new propagation theory. It is specifically useful in practical-system calibration and in exploration of complex propagation paths.

To evaluate the effects that hills, trees, mountains, etc., have on received field strengths at television frequencies, the Bureau is conducting a field-measurement program to determine the variability of the fields received and to establish the number of measurements that need to be made, both in the service area and in the fringe area of a television station. Results are being incorporated in a proposed method for estimating what the service area of each television broadcast station will be.

During the past several years, a large quantity of tropospheric propagation data has been obtained in the frequency range of approximately 50 through 1,000 Mc, but only a

small amount of data exists at higher frequencies. Consequently, the Bureau is now designing a complete radio field strength recording system to operate in the 9 to 10 kmc frequency band. It will be used to study tropospheric radio propagation mechanisms both within and beyond the radio horizon.

Also being studied are the modulation capabilities of long-distance forward scatter transmissions with highly directional beam antennas.

Recently, the Bureau evaluated the propagation conditions which determine the coverage of the Tacan system of air navigation and made recommendations for use in the common system of air navigation. Results show expected service under a large variety of conditions of channel and adjacent interference.

These studies also provide a basis for determining the number of channels required for nation-wide Tacan service, an important consideration in determining the feasibility of using Tacan in the common system.

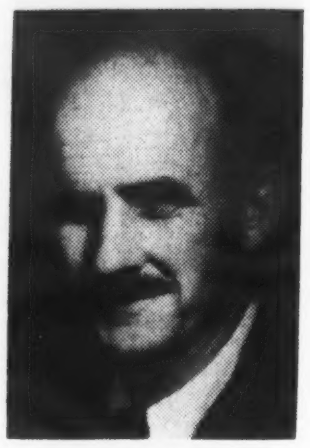
For many years, the Bureau has conducted both basic and applied research into the uses and limitations of radio propagation techniques in distance measuring and direction finding systems. To date, this work has been largely concerned with measurements required in commercial navigation. Recently, however, new applications, such as missile "navigation" or guidance, have arisen requiring a much more precise evaluation of the basic physical problems involved. More refined instruments and techniques are expected to shed new light on these problems.

During the International Geophysical Year, which began July 1, CRPL will extend its program of research and will set up many more field installations on a global basis. The Boulder Laboratories will be the U. S. Center for IGY research on the ionosphere, airglow and noise levels. Here will be located one of the three world-data centers for collecting and analyzing data on the ionosphere. At Fort Belvoir, Va., there is an IGY World Warning Center which will alert observers around the world for expected increases in geophysical disturbances so that observations can be intensified.

Results of the IGY work, when correlated with the everyday projects at the Boulder Laboratories, are expected to yield a wealth of information of direct benefit to both the basic scientific and the engineering problems of radio propagation.

CRYSTAL FILTERS

by Malcolm M. Hubbard



President, Hycon Eastern, Inc.

Recently, Hycon Eastern revealed design details and characteristics of a high frequency crystal filter which will be covered in detail in the following article. This revolutionary electronic device will enable designers of high frequency radio systems to put more radio transmitters on the air within the available frequency spectrum, in addition to a myriad of uses as yet unforeseen.

RADIO RECEIVERS OPERATE on the principle of selecting from a wide range of available energy some specific bit of energy containing desired information. To accomplish this feat, designers of radio communication systems use a scheme of filtering. For years, filters have been used to cut out, or do away with, unwanted radio energy so that desired energy can be used effectively. This is why home radios and television receivers have several filters built into them. Military radios, in general, have even more filters.

Therefore, a filter may be defined as an electronic network of components which will allow only certain signals to pass through it. Most filters are individually designed for the specific job they have to do. However, there are certain places in radio, radar and television circuits where the same type of filter often turns out to be necessary. This is why manufacturers of radio and electronic devices have standarized certain filter types. Up to now, most of these standard filters have been made of coils and condensers.

Nature has arranged things in such a way that it is easier to turn a sharp corner when there is less resistance to turning. In the case of filters, sharp corners are the desired end product. Abrupt changes in response to signals of different frequencies is what designers try to achieve in a filter. The less resistance an element has, the easier it is to bring about abrupt changes in response. Quartz, which is an extremely stable crystal substance, has the fortunate characteristic of possessing very little resistance to vibration at certain discrete frequencies. The frequency at which any particular piece of quartz crystal will vibrate without much resistance is dependent upon the dimensions of the crystal and mounting techniques. In general, a given piece of quartz crystal will vibrate easily at one specific frequency, but will not tend to vibrate at all at any other frequency. This fact is the key to filters made of quartz crystals.

Crystal filters do the same basic job as long-standing conventional filters, but they do the job much better, especially at high frequencies. In addition, crystal filters make possible the design of new types of equipment never before possible.

Single sideband radio equipment makes particularly good use of crystal filters. In single sideband transmission, effectively, half of each radio signal is filtered out at the transmitter and then later reinserted at the receiver by electronic means. The very nature of a single sideband system makes a good filter the heart of the system.

Crystal filters are desirable for high frequency single sideband systems because a crystal filter has an inherently sharper rejection ability than other types of filters. Use of crystal filters in a radio receiver, especially at frequencies above conventional home radio bands, makes possible the design of a simpler radio set than is feasible with conventional filters made of coils and condensers.

For any communication or navigation system where it is necessary or desirable to transmit and receive a narrow band of information, the job can be done better using a crystal filter than any other type of commercially available filter. In many instances the use of such a filter represents the only way to do a given job using standard, commercially available parts.

There are, in general, three types of filters commercially available. These are: (1) LC Filters; (2) Mechanical Filters and now (3) Crystal Filters.

LC filters are networks made up of coils and condensers; they represent the most conventional approach to making filters which electronics designers have used in the past. Mechanical filters make use of vibrating metal structures to filter out undesirable signals which have been transformed to vibrations. The newest and best type of filter, the crystal filter, makes use of networks of tiny quartz crystals.

High frequency quartz crystal filters are smaller, more reliable, do a better job of filtering and are simpler than their counterparts made of coil and condensers or mechanical structures.

(*Continued on page* 16)

U. S. Army Photo

Night mobility and combat power are provided for both men and tanks by infrared devices developed by ERDL.

ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES AT FORT BELVOIR FURTHER SCIENCE OF MOBILITY

Mobility is a byword at the Engineer Research and Development Laboratories, the principal military R & D center of the Corps of Engineers, U. S. Army. Work in seventeen fields of endeavor is aimed at furthering the mobility of our forces, and impeding the movement of the enemy. These fields are: bridging and stream crossing, cover and concealment, construction and maintenance equipment, infrared, liquid fuels distribution, mapping and geodesy, materials, mine warfare and demolitions, buildings, processing and packaging, water supply and sanitation, special weapons and general engineering.

About 1,500 civilians, 50 officers and 200 enlisted men work at the Laboratories. An 800-acre proving ground provides facilities for testing earthmoving, firefighting and illumination equipment, obstacles and demolitions, and mine warfare items. Environmental testing under arctic, desert, and tropical conditions is accomplished by detachments of Fort Churchill, Canada; Yuma, Arizona; and in Panama, respectively. Facilities in Greenland are employed for operational testing of construction and navigation equipment for ice cap requirements. At Prince, West Virginia, there are facilities for bridge testing. A branch at Wright-Patterson Field, Ohio, coordinates ERDL and Air Force aerial photographic activities.

Typical of ERDL's work are target location systems and equipment being created by its Topographic Engineering Department—where means of accurately locating the enemy by use of drones and many other techniques are under constant development. In other departments, vehicular navigational systems, construction equipment capable of being air-dropped, and mobile assault bridges are being developed, and the effects of atomic weapons are being determined. Many hundreds of other projects are under way at ERDL, helping to keep the Army of the United States second to none.

Technicians at Ford Instrument assembling components for vehicular navigational computers being developed under an ERDL contract.

Crystal filters make use of several wafers of quartz, usually either two, four or eight. The wafers, or individual crystals, are arranged in a lattice or bridge network configuration so that the entire network has certain desired characteristics. The characteristics desired and achieved in the filters are as follows.

Consider an antenna normally connected to a radio receiver. This antenna is susceptible to a considerable portion of the radio energy passing by it. However, the radio receiver is only useful to the listener if some intelligible information emanates from it. If all the information contained in all the radio frequencies (to which the antenna is sensitive) were simultaneously presented to the listener, the result would be a garbled hodgepodge of noise, with essentially no intelligible information resulting. So, the receiver is "tuned" to a narrow range of frequencies which contain only the information desired at one particular time.

Unfortunately, speech cannot be transmitted via radio on one single frequency. So, it is general practice to tune a receiver to a specific frequency (the one read on the dial) and which allows the receiver to pick up signals close to the dial frequency. Normally, the signals picked up, or detected, are equally spaced on both sides of the dial frequency. The resulting information which comes out of the loudspeaker is therefore a summation of information contained in a band of frequencies. The center of the band is the frequency to which the radio receiver is tuned. This frequency is normally referred to as the center frequency of a station. The band of frequencies over which intelligible information is transmitted is called just that, a frequency band. (In the case of home radio receivers, this band is a few thousand cycles in width.)

Frequency Receiving

An essential part of a radio receiver, therefore, is a filter which will discriminate against all other frequencies, exclusive of the frequency band of the station being received. Crystal filters are designed to make the receiver extremely receptive to the frequency band desired, and at the same time extremely non-receptive to unwanted frequencies outside the band.

Communication systems more sophisticated than home radios vary the basic theme somewhat. Since the range of frequencies available in nature is necessarily limited and since more and more people continually want to get on the air with information, many schemes have been advanced to make better use of a given finite band width of frequencies. One of the better schemes is single sideband transmission in which half the frequencies are arbitrarily filtered out and thrown away. This leaves the omitted frequency band available for other people to use. In order to achieve such clever manipulation of frequencies, however, extremely good filters are required. The filters must be able to allow desired frequencies through a system virtually untouched, but at the same time must suppress immediately adjacent frequencies—hence, the sharp corner. The sharper the corner the filter can turn, the higher is its "selectivity"—that is, the more nearly can the filter approach the ideal situation of allowing one frequency to pass through, but completely blocking the next adjacent frequency along the line. Here again, crystal filters approximate this Utopian situation much more closely than other existing types of filters.

The ability of a filter to have high "selectivity" is primarily determined by the "Q" of the elements used in the filter. Q, or "quality factor," is an arbitrary symbol which permits the engineer to determine how much energy is dissipated or wasted by the filter element. The higher the Q, the less the wasted energy, and therefore, the better the filter. In addition, the same filter, produced at a higher frequency, will require a higher Q for the same performance or selectivity. Conventional coils used in L C filters have Q's in the order of 200, while the elements employed in mechanical filters have Q's of about 2000. On the other hand, ordinary quartz crystals have Q's which range from 20,000 to 200,000. In other words, the crystal filter can be made a great deal better than the LC or mechanical filter at low frequencies, and furthermore, can be produced at high frequencies where the other filters will not perform.

Quartz crystals have been used for years to control the frequency of oscillation of oscillators. It has been only within the past two years, however, that any serious work has been undertaken to make commercially available the filters containing a network of quartz crystals which will allow a band of frequencies to pass. Lattice filters made up of quartz crystals were first proposed (about twenty years ago) by a scientist named Warren Mason of Bell Telephone Laboratories. However, the mathematical calculations necessary to design these networks and the difficulty of producing the necessary crystals at high frequencies caused manufacturers to shy away from crystal filters. It was Dr. David Kosowsky of M.I.T., and now at Hycon Eastern, Inc., Cambridge, Mass., who developed a highly simplified mathematical technique for designing crystal filters and devised new methods for producing and testing the required quartz crystals. Dr. Kosowsky went further on and designed shop production equipment which makes the manufacture of crystal filters almost routine. It was this latter step which enabled Hycon Eastern to bring the price to a figure which is competitive with LC and mechanical filters.

At frequencies above a few megacycles, crystal filters are virtually unchallenged by their sisters, LC filters and mechanical filters. The older type filters just won't do the job at high frequencies. At lower frequencies, where long established techniques have brought LC and mechanical filters' prices down to low figures, crystal filters excel only in performance. At lower frequencies, crystal filter prices and mechanical filter prices are roughly the same. A typical crystal filter currently sells for forty dollars when bought in small quantities, or twenty to twenty-five dollars when purchased in larger lots. As with transistors, which sold for about two hundred dollars when originally developed but which now sell for less than two dollars, crystal filters will also come down in price when they are in high production.

Design Opportunities

Athough the low frequency crystal filter will play a significant role in single sideband and telephone communication systems, the high-frequency crystal filter may well revolutionize the design of other communication and navigation systems. In addition to performance which cannot normally be obtained even at lower frequencies with conventional filters, the high-frequency crystal filter may be made extremely small in size. Models have already been produced which are about half the size of a small match box. These miniature crystal filters, in conjunction with miniature vacuum tube and transistor circuitry, are currently being employed in the design of several of the most compact communications equipment ever produced.

Biggest potential use in the next few years of crystal filters will probably be in mobile communications.

With the Federal Communications Commission constantly forcing all radio systems to operate in continuously narrower frequency bands because of crowded conditions at high frequencies, narrow band pass filters are becoming more and more significant. At the present state of the communications art, LC and mechanical filters are being used to their ultimate capabilities. The advent of crystal filters now enables equipment manufacturers to surge ahead with radio and radar systems using narrower frequency bands than were before possible.

An extremely important significance of the arrival of crystal filters on the communications scene is the possibility now of eliminating multiple conversion high-frequency receivers. Because it has been hard to filter signals at high frequencies, electronic manufacturers have utilized steps of frequency conversion to get the frequency down to a useable range. In other words, signals at high frequencies could not be easily filtered using LC or mechanical filters, so the signals have been converted to frequencies where filters will work. Often, multiple conversion receivers have three mixing stages where frequency conversion is accomplished. Each of the mixing stages requires an oscillator. In addition to the higher cost, each oscillator added to a receiver causes unwanted noise possibilities. In short, the manufacture and alignment of multiple conversion receivers is more complicated than for single conversion receivers. Crystal filters make possible the design and manufacture of single conversion receivers at high frequencies where this has not been feasible up to now.

Military and industrial users alike welcome the reliability characteristics of crystal filters. Unlike many LC filters, crystal filters need no alignment after manufacture. The quartz element is extremely stable with respect to temperature, shock and vibration. In general, crystal filters will meet guided missile specifications for environmental conditions, whereas LC and mechanical filters have great difficulty performing under the missile conditions.

High selectivity at high frequencies, extreme stability, competitive price and versatility are the outstanding characteristics of crystal filters. In the worst case, a typical crystal filter may change its parameters one part in one million over the period of a year.

looking forward to the FUTURE

I PROPOSE TO SET FORTH IN THIS article the broad objectives and goals of the U.S. Army Signal Corps in our defense program. This is appropriate when we consider that our Government today is spending just about $1100 a second, or approximately $100 million a day on military expenditures of all sorts. These expenditures are reflected in the present reorganization of the Army.

But, even without a reorganization of the major combat forces, the Army would have been required to re-equip itself with new communications-electronics gear in order to keep pace with the many technological advances being made in these fields. In looking toward the future, we find that as the Army gears itself to today's Atomic-Electronics Age, the role of the Signal Corps becomes increasingly more important.

Almost every organizational change and every new weapon adopted by the Army increases the need for new electronic devices and systems. The reorganization which is now in process to form the new pentomic divisions gives greater flexibility and fire power. It reduces the over-all man power requirements markedly. It also introduces a brand new requirement, for 600 Signal Corps officers, which did not exist before.

The accelerated tempo at which the Pentomic Army is being developed places a tremendous challenge upon every element of the Signal Corps. Considering material, we are faced with the largest undertaking since the beginning of World War II. Our energies and resources in other areas of endeavor are also being heavily taxed.

So, today, the Signal Corps is embarked on an aggressive program to bring, through development and into production, a large variety of new electronic and communication devices never before employed by the Army. Our broad objectives in this area are to develop and produce the concepts and the electronic tools and to recommend systems and organization and doctrine to the Continental Army Command (CONARC) which will provide the commander with the essential elements for command control.

The author, AFCEA contributor and supporter, prepared this article when he served as Chief of Combat Development & Operations Division, OCSigO. He recently assumed the post of Deputy Commandant of the Industrial College of the Armed Forces, Ft. McNair, Wash., D. C.

The provision of command control is the principal task of the Signal Corps and it will remain so in the Army of the future.

Just what is meant by the term "command control?" An accepted definition of the term is: "The systematic employment of devices and techniques designed to acquire data and transmit information essential to the control of friendly military forces, and, to counter the enemy's command control system."

If you analyze that definition for just a moment you will find that it has three basic elements: (1) signal communications, (2) combat surveillance and (3) electronic warfare.

The Signal Corps is developing basic systems for each of these 3 elements along with interworking systems for each level of employment, i.e., division, corps, army and theater. Each, of course, will supplement the others. The practice of piecemeal introduction of new equipment has been abandoned in favor of complete systems which will include provisions for equipment, personnel, organization and maintenance support.

In the approved concepts of the new Army in the field, command control has taken its place along with firepower and mobility as one of the 3 basic determinants of victory. This places it squarely up to the Signal Corps to prove that it has the technical competence to provide the Army with this capability.

THE pattern has been pretty well set for the composition of the basic team in the new mechanized divisions. As I visualize it, this team will be comprised of battalion-sized composite units of infantry, armor, artillery, engineer and signal troops. These units will be armed with ballistic rockets and guide missiles, using conventional or atomic warheads. The units will be highly mechanized, will have substantial organic aviation and will be capable of operating at distances of 50 miles or more from adjacent units or higher headquarters. This mobility, atomic firepower and dispersion could represent confusion and even self-destruction without adequate command control capabilities.

The kind of communications we envisage for 1960-1970 involves new techniques of radio having long range, greater capacity and design to offset the enemy's jamming efforts. In the use of radio relay, for example, our objective is to double its use-

fulness and, at the same time, reduce the number of technicians required for operation and maintenance.

Another objective in the communications area is to develop new types of wire which can be laid by helicopter, drone or missile, and which can successfully transmit its message even though it may be broken in a half-dozen places.

Perhaps the most widely known change in the field of Army communications is the "Area Communica-

tion System" concept. This system has been designed to insure that the new type combat groups will, at all times, be tied into a flexible communication system which can be deployed throughout the combat zone, so that no matter how it moves or how it is displaced, it can talk to communications central which can rapidly link the unit commander with adjacent troops.

Requirements

In the face of enemy atomic warfare capability and the accompanying supersonic delivery systems, a strong requirement is generated for a comunications system capable of absorbing the impact of atomic attack and capable of quick reaction to meet changes in operational plans and in task organization. The increased emphasis of direct operational and administrative communications also dictates a departure from the present echelon-to-echelon concept.

This new system must be capable of supporting the requirements of the combat surveillance system, the electronic warfare system, the air navigation and traffic control system and the various weapons systems which evolve from technological improvements in methods of target acquisition and delivery of missiles. To meet these requirements, this new communications system is being perfected to meet the following characteristics:

a. It must be designed to provide communications to widely dispersed units and installations. It must minimize the need for support units to concentrate around one or two major communications centers located along a single axis of communication.
b. It must be a flexible system which can readily accommodate itself to changes in organizational structure and to re-locations or concentrations of units, command posts and installations. Its structure and patch-through facilities must permit electrical rerouting and physical re-locating of circuits with a minimum of changes in the system. Systems' components must be made up of building block type units so that rapidly changing requirements can be met by adding or removing unit elements to meet specific conditions.
c. It must be a reliable system, designed to provide continuity of communications in the face of enemy action. Destruction of a portion of the system by an atomic weapon, for example, must not disrupt the entire system.
d. It must be a common user system, designed to provide communication (particularly trunk-line service) for installations and units which would otherwise use organic facilities. Its other features must make it adaptable to provisions of special purpose circuits required to coordinate the employment of new weapons systems and for other special operations.
e. It must have a high capacity potential designed to meet the extensive demands placed on it.
f. It must be a high quality system designed to reduce the degradation of service which would otherwise result from the distances involved under the new concepts.
g. It must contain sufficient mobile elements to keep pace with movements of the Field Army. To create the degree of systems flexibility required, these facilities must be mounted in vehicles, vans or transportable shelters.

The most significant features of the area communication system are:

a. A lattice work of high quality, high capacity communication links, with signal centers at each link intersection.
b. An increase in the use of multichannel radio relay and field cable systems, with a major decrease in the use of pole line type of construction and single circuit systems.
c. Development of the communication means, which serves the several command echelons, into components of an over-all integrated system rather than a group of independent facilities.
d. An increase in the capacity and operational quality of equipments, and in the mobility and flexibility of employment.

Also, there will be provided greater flexibility in tactical communications. Under this system, there will be almost instantaneous switching of voice circuits to any combat group or unit within the combat area. This concept will, of course, virtually eliminate the use of wire in its area.

Combat surveillance is a new name which has been applied to one of the most difficult facets of ground combat—i.e., obtaining information of the enemy and keeping abreast of both friendly and enemy activities on the field of battle.

Combat surveillance is a continuous, all-weather, day and night systematic watch over the battle area to provide timely information for tactical ground combat operation. Combat surveillance includes friendly as well as enemy information obtained by both technical and non-technical means. The Army's combat surveillance system is the aggregate of all means of collecting information of the enemy, weather and terrain, and the means required to process and display this information rapidly and effectively to the commander.

Military leaders within the U. S. Army have recognized the vital importance of maintaining our combat surveillance/target acquisition capability, commensurate with the maneuver and fire capability of the Pentomic Field Army.

The U. S. Army Combat Surveillance Agency (USACSA), commanded by Brigadier General William M. Thames, was established in January 1957 with offices in the Pentagon. USACSA is directing the Chief Signal Officers' effort toward improving the Army's combat surveillance/target acquisition capability in consonance with the Pentomic and Pentana Army concepts.

A combat surveillance equipment system consists of several subsystems or main elements:

a. The information-collecting devices, with their aerial platforms, if appropriate.
b. The data link or electrical communications means required to transmit the information gathered by the collecting devices to a central station.
c. Processing, evaluation and collation of information to produce intelligence.
d. Display of the information and/or intelligence to the commander and staff in a useful and effective manner at appropriate echelons.

Means and Devices

For the collection subsystem, several means may be used. All of the tried-and-true means of both World War II and the Korean conflict, such as photography, patrols, observers and interrogation of PW's, are still used, and added to that family are new or improved surveillance means such as infrared, radar, television, acoustic and seismic, U.S. Army Signal Corps equipments. These devices include the 100-inch camera, infrared scanners, ground radars, sidelooking airborne radar (SLAR) and many others.

(Continued on page 32)

by C. F. Flannell
Royal McBee Corp.

THE small COMPUTER

and Decentralized Computing Facilities

DIGITAL COMPUTERS OF CONTEMporary vintage have made two major contributions in scientific and engineering applications which were hardly possible for computers of pre-electronic vintage. First, they have solved many problems which would be too large for even a lifetime of horse and buggy methods of calculation. Second, by assuming the burden of repetitious computations, they have provided engineers with more time for creative thought.

So valuable are these contributions to industrial technology that they have stimulated a remarkable development in the size and speed of computers. The giant brains are providing engineers with answers of precise accuracy in cases where educated guesses were previously the rule. The wide margin of safety provided with the educated guess resulted in the design of inefficient equipment creating continuously high costs of operation. In other cases, cut and try methods involving the building and testing of prototypes of trial design were used. Now the testing of many trial designs can be simulated at electronic speeds to eliminate the expense of building and testing actual prototypes. Recognizing the importance of such developments, the engineer is quickly accepting the giant brains available to him.

However, the use of giant brains is not without its price. While computers have grown to be very large and very fast, they have also grown to be very expensive and very complex. The expense requires critical scheduling for efficient use and the complexity makes scheduling difficult. In addition, efficient computer operation requires highly trained personnel who are difficult to find. Furthermore, the large computing installation is not flexible enough to keep up with the fast-changing demands of the engineering group. Hence, after the engineer learns to rely upon the giant brain and use it regularly, it becomes the source of several major obstacles.

The first obstacle an engineer faces in getting a problem solved on a giant computer is having the problem programmed, that is, put into machine language. I had personal contact with this problem during my employment in a large computing installation of an aircraft company. The last problem which I programmed had waited to be programmed for over six months. The engineers finally had to make a decision on the metal to be used in an air frame before they received the results of our heat calculations. Our calculations showed that the temperatures involved would stay slightly below the melting point of the metal selected by the engineers. If they had guessed wrong, thousands of dollars and a great deal of time would have been lost. This was a very important problem and the engineers were very unhappy with this computing service. Many groups waited even longer for their answers.

The second obstacle an engineer encounters in having a problem solved on a giant computer is the dual problem of communication and scheduling after the programming is completed. The data must be sent to the central installation each time a run is made. The large companies which have the large computers frequently are widely dispersed so that inter-office mail may require a half day for delivery. After the data arrives, it must be logged in, assigned a priority, punched in cards or tape for entry into the computer and held until the machine becomes available. Only then are the answers returned to the engineer.

In some situations, the obstacle to communication created by the large computer installation is even more critical. For many engineering groups, one day or even one week's service from the computing group is quite adequate; nevertheless, many engineers want their answers within a few minutes. One good example of this demand for quick results is in aerodynamic wind tunnel applications. In many cases when a wind tunnel test is completed, the engineers want to see the results of that test before they set up the next test; this requires that the pressures, temperatures and other measurements which were taken during the test be reduced to physical quantities which are meaningful to the engineer. Such a situation provides an ideal application for a computer. However, if the engineer must wait a day for these results, not only is his work less effective but also expensive wind tunnel equipment is inefficiently used. Therefore, such a delay represents a considerable financial loss to the company.

There are many other cases where immediate results are desirable. For instance, in research problems, the engineer may first try a given set of values and then when he sees the results he may want to change one number slightly to observe the effect on the answers. If he must wait a day or two for his answers, he is less inclined to try a new value. When he gets an answer which is close enough, he is inclined to draw his conclusions without trying for a more accurate answer. Hence, it appears that the barrier to communication with giant brains stultifies the experimental spirit.

In spite of this discouraging picture, a great deal of progress has been made toward improving the system of communication with the central computing installation. One method of improving communications is to feed data directly to the computer and receive answers immediately. Such a system in its ultimate form would be very complex indeed, and, with current techniques, is still impractical. The alternative method is to locate a computer at each source of data. The introduction of the small computer has made such decentralization possible. Hence, many large organizations have become interested in a decentralized operation as a method of increasing the efficient use of their personnel and of breaking up the bottleneck created by giant brains.

Some electronic engineering companies have responded to this inter-

est by developing very versatile small computers. Many of the building blocks for these computers were developed for use by military aircraft and ships where limitation of component size is important. The General Precision Equipment Corporation is using such building blocks in developing small electronic computers. The Royal McBee Corporation, which has developed an international sales and service organization for its typewriters, office equipment and business systems, is marketing these computers. These two organizations have combined their facilities to produce and market the Royal Precision line of data processing equipment. One of these products is the LGP-30 computer, a small electronic computer designed primarily for scientific applications.

What comparisons can be made of the small computer with the large computer? First of all, recent developments with magnetic drum and disc memory systems have made it possible to produce a large memory in small computers at a relatively modest cost. Furthermore, a small ratio of physical size to effective circuitry can be maintained by the use of time-sharing of components. As a result, it has been possible to develop a truly general purpose computer of small size. Hence, the modern small computer can solve any problem which can be solved on the large computer; the only real difference lies in the time required for problem solution and the amount of human supervision required. Modern design techniques, then, have made it possible to put a very powerful computer in a very little space.

A second point in favor of the small computer is the ease of installation. Computers have been developed with remarkable capacity which occupy less space than a normal office desk, which operate from a standard wall outlet and which require no more power than an ordinary home iron. For such computers, no air conditioning is required and hence no major overhaul of buildings to house them as required for large computer installations. The cost of installation of such a computer is practically zero.

Principal Uses

There are three principal ways in which small computers are being used today. One way is the use of several small computers as satellites to a large computer in order to reduce the difficulties attending the use of the large computer. Another is the use of a group of small computers to replace a large computer. A third way is the use of the small computer, by itself, as the principal computing device for a company, division or department. The expense of the large computer makes its use in this third case prohibitive. There are several interesting examples of such uses of small computers. Here is one.

The head of the computing department of a large aircraft company, after a six-month feasibility study, recommended to management that they open the bottleneck of the central computing installation by purchasing a group of small computers to be located in various engineering departments. Their central computing installation operates on an "open shop" basis where the engineer does most of his own programming. This programming is simplified by an algebraic interpretive routine which translates algebraic expressions into computer language.

The programming procedure was to remain unchanged with the installation of the small computers. The engineers would continue to program their problems in algebraic form using the interpretive routine to translate this algebra into machine instructions. The engineer who had a small computer in his own department would use an interpretive routine which would produce a program for the small computer rather than the large computer. The engineer then would return to his small computer where his problems could be solved without the delay of sending the data to the central installation and waiting for it to be returned a day or perhaps a week later. With this system, the engineer would make only one trip to the central installation or send information to the central installation only one time. Then he could continue to use his program, independent of the central computing installation, until he chose to solve another problem on the computer or make a major modification of the existing program.

The LGP-30 computer was recommended for this application because its order structure is compatible both with the large IBM computer and the Univac computer which this aircraft company is using. They planned to punch the program on IBM cards and use a card-to-tape converter or, if the Univac computer was used, they would punch the program tape directly from the computer. The engineer would return to his department

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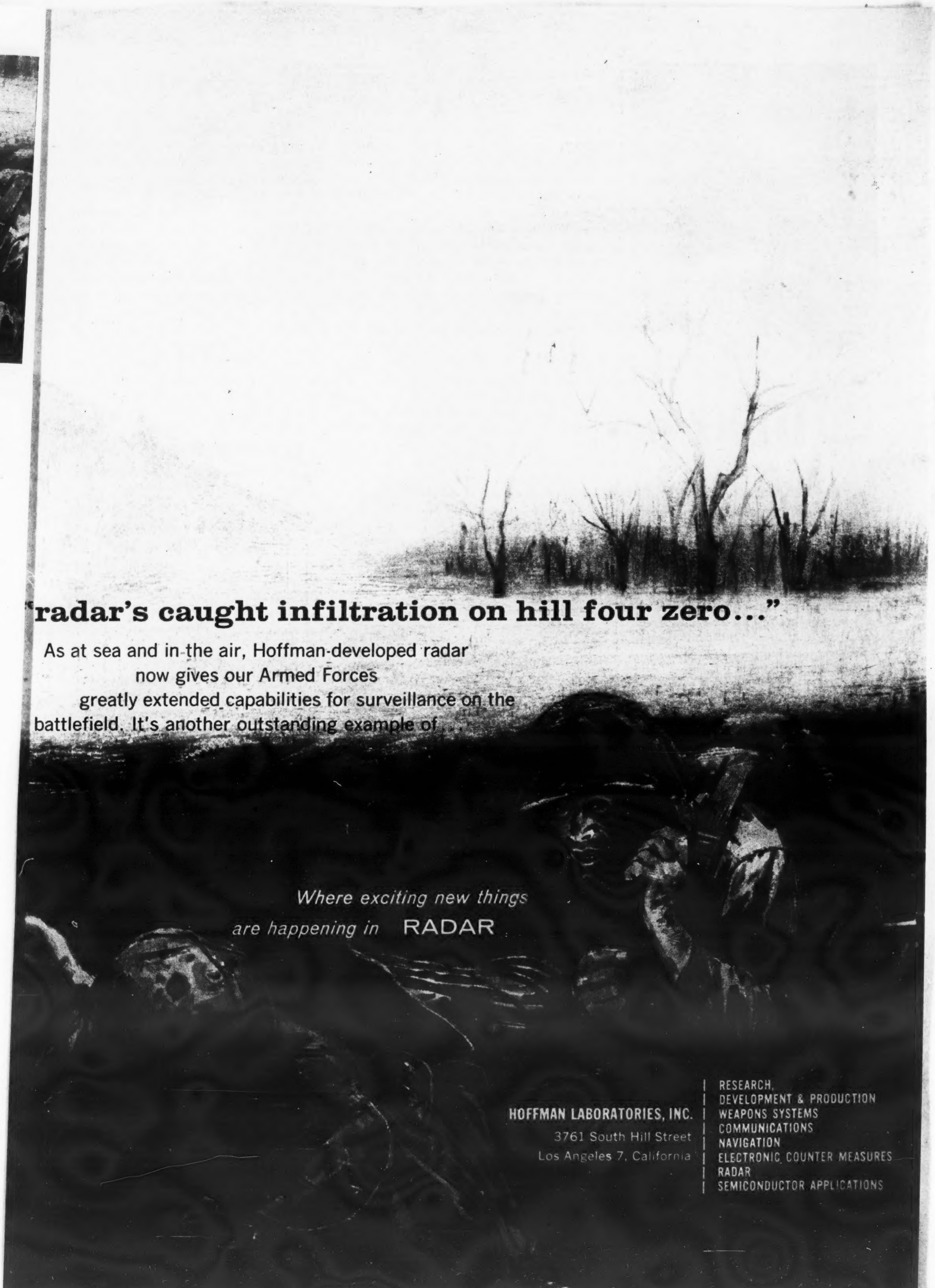
"radar's caught infiltration on hill four zero..."
As at sea and in the air, Hoffman-developed radar now gives our Armed Forces greatly extended capabilities for surveillance on the battlefield. It's another outstanding example of . . .
Where exciting new things are happening in RADAR
HOFFMAN LABORATORIES, INC.
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Los Angeles 7, California
RESEARCH,
DEVELOPMENT & PRODUCTION
WEAPONS SYSTEMS
COMMUNICATIONS
NAVIGATION
ELECTRONIC COUNTER MEASURES
RADAR
SEMICONDUCTOR APPLICATIONS

with a program tape ready for entry into the small computer.

The LGP-30 has been chosen to augment a large computer installation in another way. The compatibility of LGP-30 code with the codes of large computers has led to its use in program check-out. Anyone who has worked in a central computing installation realizes that an engineer rarely states his problem in the first writing exactly as he wants it; invariably he wishes to make additions to the program or changes in the program almost immediately upon its completion. Debugging of new programs and revision of programs consume a great deal of machine time and when the machine involved is a giant computer, time can be very expensive. In working through parts of a problem to find the source of difficulty, the greater speed of a large computer is of no advantage. An inexpensive man tends to become the slave of an expensive machine.

Hence, some people have chosen to eliminate this expenditure of valuable machine time by placing new problems on a small computer for solution until the details are formalized and a satisfactory program is developed. Then if the volume warrants, the program is translated to the language of the large computer. In this type of operation, the small problems and the "one-shot" problems never reach the large computer. This approach has another advantage besides the saving of money. It reduces the pressures which are exerted toward standardization of procedures. The engineer can feel free to try new approaches to his problem on the small computer while his old approach is being employed on the large computer.

Other Applications

Some large companies are taking still another approach to the application of small computers. Management has chosen to let each large department or division select a computer which will satisfy its own needs. The computing facility is on a completely decentralized basis. By having the computer close at hand, the engineer is encouraged to make good use of it rather than waste his time on a desk calculator or content himself with educated guesses or "ball park" answers. For this type of installation, care should be taken in selecting a computer which is relatively simple to program and operate so that the engineer can spend more time concentrating on finding methods leading to more accurate answers than on programming and operating the computer.

Another interesting application of a small-sized computer on a decentralized basis is its use as a special purpose computer. A major oil company is using an LGP-30 in one of its refineries. The computer has been set to assist in the one difficult task of finding a combination of operations that will produce the desired motor fuels on any particular day from the crude that is presently available. In this application, the use of a central computing service is inadequate because immediate answers are important. Accurate solution of this problem can mean as much as $.01 per barrel difference in profit. Since over 100,000 barrels per day are involved in this operation, computation can make as much as $1000 difference in profit per day.

Capacity Considerations

The small company which cannot afford the price of a large computer or does not have enough work volume to warrant the use of a large computer, may find use for an installation similar to that in a department of a large company. Similar considerations should govern their choice of a computer. However, in addition to such things as ease of operation, they must also consider the capacity of the machine. In the small company when a problem is encountered which is difficult to squeeze into the small computer, there is no large computer standing by which may be used. Hence, it becomes even more important for the small company to select a computer which has a capacity adequate for the broadest range of problems they expect to encounter.

In summary, the speed and capacity of modern digital computers have greatly broadened the effectiveness of scientific and engineering efforts. The recognition of computer usefulness has been the impetus for the development of the giant brain. However, useful though it is, the giant brain is attended with difficulties. These difficulties can be overcome in many cases by the use of several small computers, either to augment the large computer or, in some applications, to replace it. In addition, the small computer can be used in cases where computing volume and cost factors make the use of no other computer possible. We can expect that the recognition of its great potential will generate in the coming years a remarkable expansion in the use of the small computer.

The Director of Naval Communications Looks at ....

Value Engineering

COMMUNICATIONS EQUIPMENT AND systems are fast becoming one of the more complex and expensive factors in the military electronics field, which is reason enough why we are thoroughly sold on the Value Engineering Program of RAdm. A. G. Mumma, USN, Chief of the Bureau of Ships.

As Director of Naval Communications, I am reminded daily that modern warfare tactics are placing an ever-increasing demand on communications, regarding both quantity and quality. In order to fulfill our communication objectives, it is becoming necessary for us to resort to unconventional methods of modulation and propagation and to concentrate on optimized equipment and systems for specific applications. Communications equipment and systems are fast becoming one of the more complex and expensive factors in the military electronics field.

We are faced with the reduced purchasing power of the dollar, the continued rise in costs of materials, man power and services, as well as curtailed Department of Defense appropriations. Therefore, it is mandatory that each of us does his utmost to reduce costs wherever and whenever practicable, as long as such reductions do not jeopardize the essential performance characteristics necessary to meet our operational needs.

By Navy definition, value engineering "includes an intensive and critical review of the operational and maintenance requirements, specifications, design, manufacturing processes, materials, inspections and testing by the contractor of the equipment to determine the minimum functions and parts, and the least expensive materials, processes and procedures necessary to produce a functional, maintainable and reliable equipment," with a view toward reducing the total costs of the equipment without "adversely affecting the essential characteristics."

The Procedure

The intensive and critical review of operational requirements brings the operators into the value engineering fraternity. They, the users of the equipment, must apply the value engineering concept when stating their operational requirements. This is the first step to insure that the requirements reflect the minimum acceptable functions and reliability which the operational people consider they can tolerate. Following this, the line of communication must be kept open between the operational people and the technical people who translate these requirements into design, development and eventually, hardware. If, at any level, a stated operational requirement appears unrealistic of accomplishment at reasonable cost, this fact should be brought to the attention of the operators, as represented by the Chief of Naval Operations, for reconsideration.

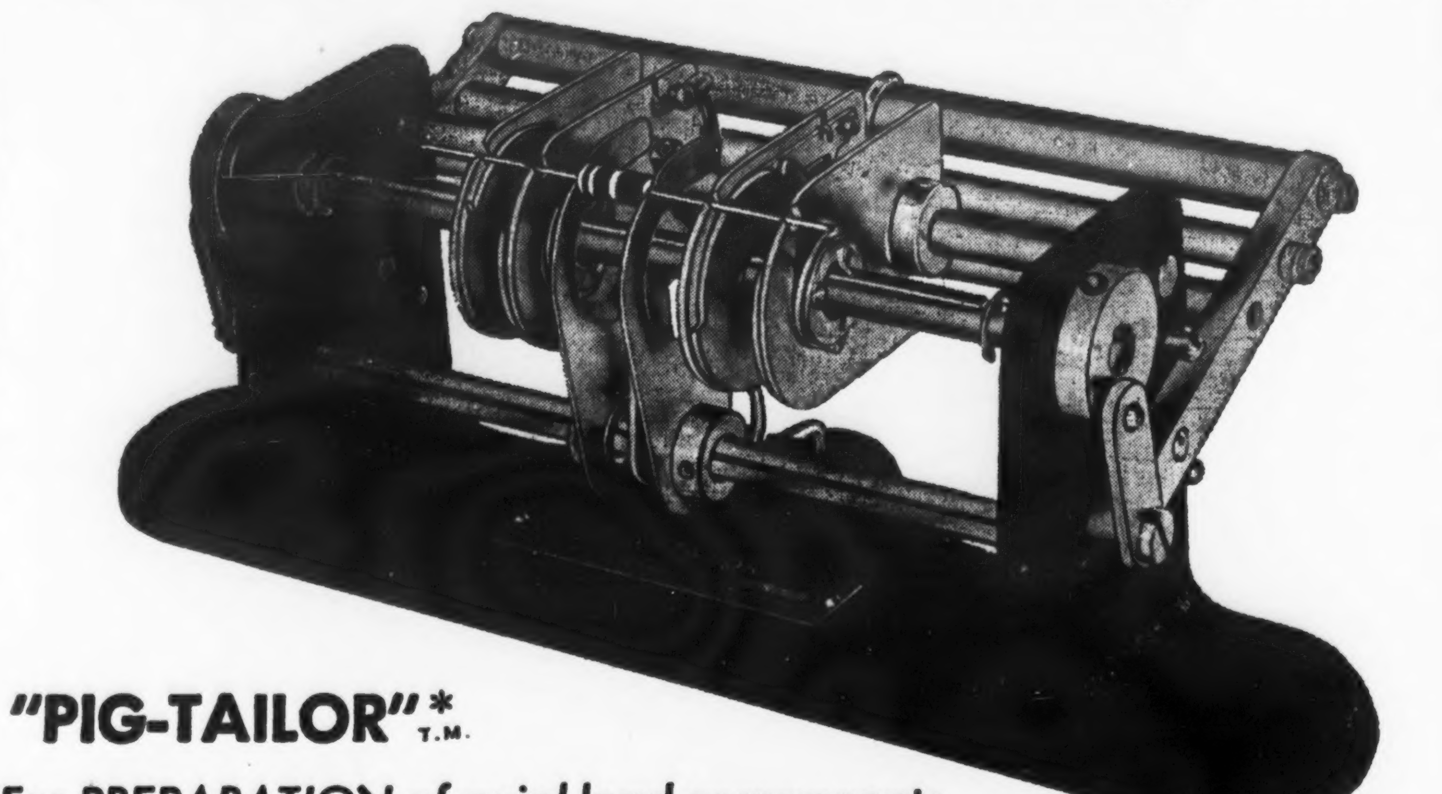
In this connection, the following is an extract from the Chief of Naval Operation's directive on Navy Research and Development Planning and Management Procedures, which is required to be included in the operational requirement document:

"In all material developments, the Chief of Naval Operations considers timely availability and suitability of first importance. Considerations of cost, critical materials, and man power are of almost equal importance. The performance figures given in this requirement are goals, except where specifically noted as minimums. During the course of planning for this development, it may be found that in meeting these goals a large and complex or costly article will result; whereas it may be found possible to develop a much simpler and therefore more readily available, reliable and suitable equipment short of the ultimate specified, but which, nevertheless, will constitute a considerable advance over presently available equipment. Determination of such alternatives should be considered an essential part of the preparation of the Technical Development Plan. In the submission of the Technical Development Plan, the developing agency shall inform the Chief of Naval Operations, or the Commandant of the Marine Corps, as appropriate, of the results, with respect to the factors enumerated above, in order that consideration may be given to making an appropriate modification of this

(Continued on page 27)

by RAdm. H. C. Bruton USN

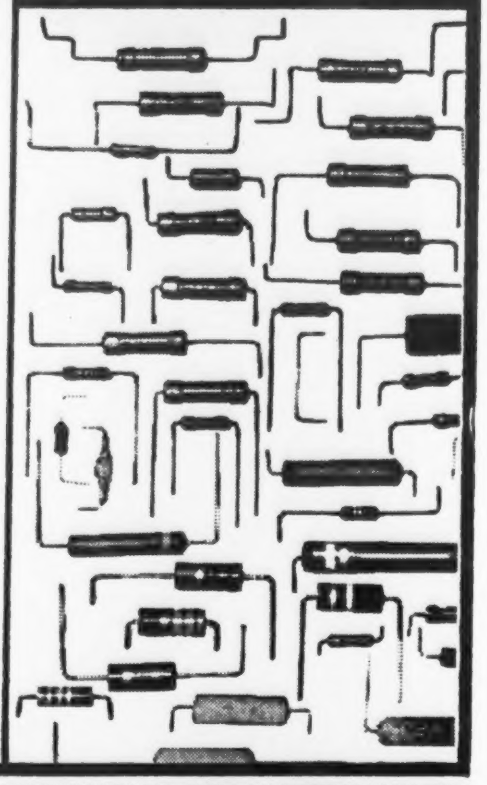
PROVEN- on the assembly line!



"PIG-TAILOR".* T.M.

For PREPARATION of axial lead components

PREPARED COMPONENTS IN SECONDS WITH THE "PIG-TAILOR"



"PIG-TAILORING"

. . . . a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.

The "PIG-TAILOR" plus "SPIN-PIN"—accurately MEASURES, CUTS, BENDS, EJECTS & ASSEMBLES both leads simultaneously to individual lengths and shapes—3 minute set-up—No accessories—Foot operated—1 hour training time.

PIG-TAILORING provides:

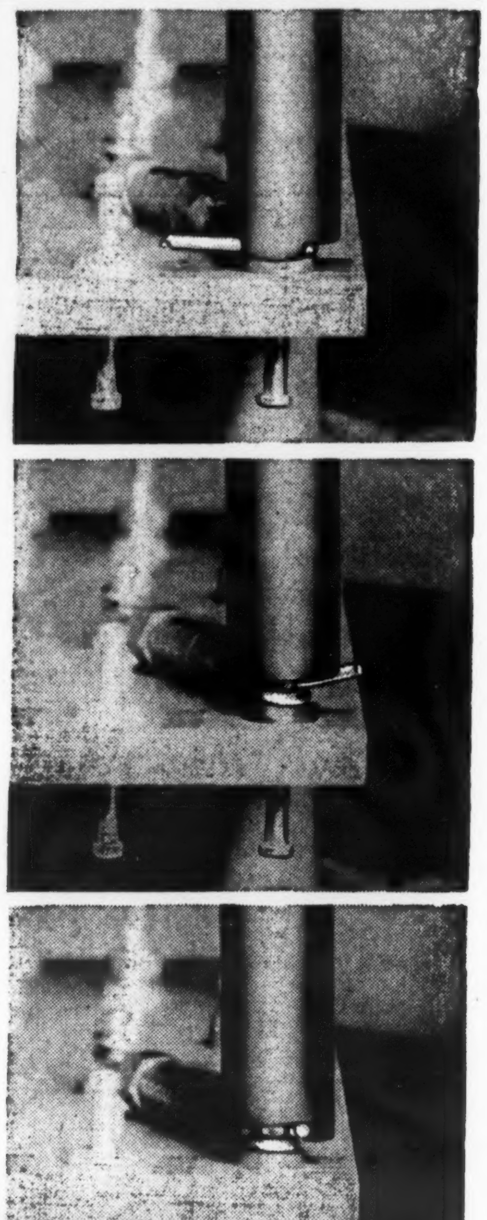
1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters!
2. Long-nose pliers!
3. Operator judgment!
4. 90% operator training time!
5. Broken components!
6. Broken leads!
7. Short circuits from clippings!
8. 65% chassis handling!
9. Excessive lead tautness!
10. Haphazard assembly methods!

FOR ASSEMBLY

"SPIN-PIN".* T.M.



Close-up views of "SPIN-PIN" illustrate fast assembly of tailored-lead wire to terminal.

* PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. S-12

BRUNO-NEW YORK INDUSTRIES CORPORATION

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operational requirement."

Establishment of the formal operational requirement document is one of several procedural steps which is required in the control of material procurement for the operating forces of the Navy. In response to the operational requirement, the cognizant technical bureau of the Navy, such as the Bureau of Ships, prepares a recommended Technical Development Plan and includes proposed development characteristics for equipment and systems which will meet the requirement. If approved by the Chief of Naval Operations, the Technical Development Plan and development characteristics are promulgated to the cognizant technical bureau for implementation.

The development cycle leads to the development of prototype material and equipment, which is accomplished under the direction of the technical bureau. Throughout the development phase, effective coordination between the Chief of Naval Operations and the bureau involved is necessary to insure close adherence to the desired objective.

Evaluations

The prototype material and equipment is then manufactured in sufficient quantity only to provide for evaluation. The evaluation usually is in two phases, namely, technical evaluation and operational evaluation, and they should be accomplished in that order.

The purpose of the technical evaluation is to determine by engineering tests the ability of the prototype to meet the technical requirements, and to determine the suitability of mechanical, electrical and maintenance engineering from the standpoint of design and selection of components. This technical evaluation is accomplished by the developing agency, that is, the cognizant technical bureau, assisted by the operating forces as necessary, and is the means for determining whether the prototype meets the specifications and is suitable for the next step: an operational evaluation by the potential customer, the operating forces.

An operational evaluation is the test of an equipment or system under service operating conditions, to determine the ability of the equipment or system to meet its specified operational performance requirements, and to determine its over-all suitability for service use. The operational evaluation is accomplished by an operational unit; in the case of equipment or systems designed for shipboard use, by a unit of the forces afloat; in the case of material for use by supporting activities ashore, by one of those units ashore. Most of the forces afloat type of operational evaluations are performed by the Operational Development Force, U.S. Atlantic Fleet.

After a review of the results of the operational evaluation, a final decision as to the suitability of an equipment or system is made by the Chief of Naval Operations. This final approval as to suitability for service use is a prerequisite to the release of newly developed equipment and systems for production. The production phase of material procurement is then undertaken by the technical bureau, and delivery is scheduled in the quantities required to meet the needs of the operating forces.

I have outlined the major procedural steps that must generally be taken in the management of material procurement for the Navy's operating forces with the purpose in mind of showing, first, how the Chief of Naval Operations fits into this picture, and second, his interest in obtaining the highest degree of readiness in the fleet. This is because the Chief of Naval Operations has paramount responsibility for all matters which affect the military effectiveness of the operating forces of our Navy.

Program Requirements

Now, from the standpoint of the Chief of Naval Operations, how is all this related to value engineering?

First—Equipment and systems developed by the technical bureau and contractor team must perform the functions that are necessary to meet the requirements of the Navy. If those requirements are not in fact met, the equipment can be considered a failure and any money spent on its procurement would not be wisely spent. This does not mean, of course, that the operators should not revaluate their requirements, and temper them when they can.

Second—The new equipment should be a significant improvement over that which the Navy may now have in use in the same general area. If it is not a significant improvement, we are not making progress. Relatively, we are losing ground instead of maintaining or enhancing our readiness.

Third — The equipment must be reliable. It must be ready to perform its function when needed. Otherwise, we would be better off without it, since we would have spent money procuring and installing it, while wasting valuable space and weight, particularly on shipboard or in aircraft.

Fourth—It must be maintainable. An equipment that cannot be maintained by the operational and technical personnel on board our ships and stations is equipment that cannot be depended upon to perform its function when needed. In this connection, we have had too many equipments with "unmaintainable" complexity introduced, intended to simplify operation. The result often has been equipment which we could neither operate nor maintain.

Fifth—Closely related to its maintainability, the equipment must be such that it can be logistically supported. It must not overburden our supply system with a large number of peculiar parts or make excessive use of critical materials.

Sixth and last, but by no means least—The equipment cost must be such that we can afford it in the quantities needed to meet the requirement. Excessive cost can very well mean that a vital operational requirement cannot be met. In other words, excessive cost can price the Navy's material readiness in a particular area out of the market.

I am glad to note that the Bureau of Ships' Value Engineering Program places a much needed emphasis on the cost factor, while at the same time, requiring that the essential characteristics of the equipment not be adversely affected.

The Bureau of Ships' Value Engineering Program is primarily a technical and contractural matter between the Bureau of Ships and its contractors. The benefits resulting from this program are, however, of vital interest to the Chief of Naval Operations, who, as I have indicated, has paramount responsibility for all matters affecting the military effectiveness of the Navy.

Lines of Communication

As I see it, there are two lines of communications required for effective value engineering:

First—between the office of the Chief of Naval Operations and the Office of the Chief of the appropriate bureau—in this case, the Bureau of Ships. The operational requirements are set forth by the Chief of Naval

(Continued on page 32)


"HOT STUFF" coming through . . .
A vital product need just ahead on the horizon lies in the field of INFRARED*. For detection of any potential aggressor, Hot stuff* comes through! IR* has numerous significant advantages: target size is not critical . . . a passive seeker, it never divulges its source or location . . . will outperform radar of comparable dimensions. IR can't be jammed . . . when detecting, it can't be detected. LMEE . . . pioneering these advantages . . . has the research and production facilities to make all this a protective reality today. Its Advanced Electronics Center at Ithaca, New York, has an INFRARED Projects Group staffed by recognized authorities on IR development. INFRARED by LMEE . . . with its broad applications to Airborne Weapons Control Systems . . . is another LMEE contribution to new uses of Defense Electronics. For information on IR . . . write Section D.
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WEAPONS CONTROL RADAR • SEARCH RADAR • INDICATORS AND DISPLAY • COUNTERMEASURES • NAVIGATION
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FRENCH ROAD, UTICA, NEW YORK

— GOVERNMENT —

NAUTILUS NOSES UNDER ICE The nuclear-powered Submarine NAUTILUS has scored another first by spending five and a half days under the Arctic ice pack, traveling a distance of more than a thousand miles. The cruise was made to obtain data on under-ice conditions, oceanographic studies of currents and on cold weather operations of equipment and machinery. As a result of this experiment, it is predicted that trips of longer duration under the polar ice cap will become an actuality.

BATTERY VEST A new battery designated for Army use can be worn as a vest. The flexible battery supplies power for a soldier's portable radio receiver and transmitter and works especially well in cold regions where a conventional battery's life-span is very short. The battery is made of two panels, each with a number of dry cells spaced and insulated from each other, but connected to make up the battery itself. The dry cells are heat-sealed in a waterproof polyethylene plastic and mounted on the vest-like garment.

AF RELEASES COMMUNICATIONS-ELECTRONICS DATA The U.S. Air Force's volume of communications-electronics data is now being converted into a series of short manuals containing information on basic concepts, planning systems and operating practices. Known as Air University Project 4736, the program is expected to require from 12 to 18 months and is being undertaken by Maxwell Air Force Base of Alabama.

ROTI MARK II The Air Force is using a recording-optical-tracking-instrument to photograph missiles in the earlier stages of their flight. Designated ROTI Mark II, the device begins its tracking duties following launching operations at the Missile Test Center, Cape Canaveral, Florida. This instrument is one of a series of systems designed, developed and built by Perkin-Elmer Corp., Norwalk, Connecticut. (A prototype model was a cover feature of the August issue of SIGNAL.)

CONTRACTS: ARMY: Western Electric Co., continued development work on the NIKE-ZEUS, $5,086,481; Telecomputing Corp., Whittaker Gyro Division, gyros, $138,621; General Electric Co., digital computation operation, $257,913. NAVY: Lockheed Aircraft Corp., continued development on POLARIS, $62,100,000; Admiral Corporation, production of electronics equipment, $1,196,000; Stromberg-Carlson, tactical air navigation system test equipment, $3,740,000. AIR FORCE: Hughes Aircraft Co., electronics equipment, $4,194,320; Bendix Aviation Corp., components of compass systems, spares and ground support equipment, $1,532,639; Remington Rand, Univac computers for TITAN, $24,000,000.

— INDUSTRY —

TOP DEFENSE CONTRACTOR IN U.S. The Boeing Airplane Company has displaced the General Motors Corporation as the No. 1 dollar value defense contractor. A report issued by the Pentagon, covering the six and a half years ending last December 31, showed the airplane producer in the top position for the first time, but followed closely by the motor car manufacturer.

RADAR PATENT After 20 years, a patent for significant military and commercial radar developments has been granted to International Telephone and Telegraph Corporation. Awarded on an invention by P.F.M. Gloess, a French scientist formerly with IT&T's Paris laboratories, the patent covers the practical form of radar generally used today on ships, airplanes and for defense purposes. It is known as plan position indicator (PPI) radar. The disposition of an entire fleet of ships can be shown on the face of a cathode-ray tube and the exact position directly read from the distance and angular scales on the tube. The invention similarly will show the contour of land ahead of and below an airplane, will draw a picture of the coastline for a ship approaching at night or in fog, or will reveal the position of attacking aircraft or missiles.

EXCHANGING VIDEO TAPE PATENTS An agreement for the exchange of patent licenses covering video tape recording and reproducing systems for black-and-white and color has been signed between Radio Corp. of America and Ampex Corp. These systems enable the recording on magnetic tape of scenes, information and sound for later reproduction, not only for television broadcasts, but also for other professional and commercial purposes.

CREI COURSE A new course, "Control Systems Engineering Technology," is being conducted at Capitol Radio Engineering Institute of Washington, D.C. The session concerns the combined relationship of servos, computers and radar in their varying applications of pulse techniques. Students successfully completing the course at the residence school will be awarded an Associate Degree in Applied Science.

3-DIMENSIONAL COLOR TV The first closed-circuit 3-D color TV system, developed by General Electric Co., of Syracuse, N.Y., allows remote servicing of reactors used in the development of a nuclear aircraft propulsion system. Including the first use of color TV with stereo, the system permits use of color-coded parts in reactor components and provides the degree of precise depth perception required for the correct positioning. The system is not currently feasible for the living room.

— GENERAL —

THE NEW $ LOOK On October 1, a new U.S. dollar bill went into circulation—the first of new design in 22 years. Identification marks are: 1) The legend "In God We Trust" on the back of the bill is a new addition. 2) "Series 1957A" is designated under the seal on the face of the bill. 3) The portrait of George Washington appears a little changed. 4) The signature of the new Secretary of the Treasury, Robert B. Anderson, appears for the first time.

IRIA An Infrared Information and Analysis Center has been established at The University of Michigan's Engineering Research Institute. Purpose of the agency is the "collection, analysis and proper dissemination" of information about infrared research and technology with particular emphasis on military technology. All data that will advance this program is collected with particular attention to acquisition of up-to-date contractor reports. Analyzed for content and value and catalogued according to type of research or technology discussed, the information enables IRIA to provide contractors with proper information concerning a specific development or with evaluative surveys of broad trends of research and development.

NATO SCHOLARSHIP FUND A bipartisan group of American legislators unanimously decided to triple the scope of a proposed NATO science talent development plan to meet the Soviet threat of the "Sputnik age." The original plan which called for creation of an annual NATO scholarship fund of $2 million has been increased to approximately $6 million, which would provide for about 600 new doctorates in the science field a year. The United States presently grants about 450 such degrees annually and the other NATO members combined somewhat fewer.

AIR CONTROL POSTPONED Civil Aeronautics Administration planned to take over control of all airspace above 24,000 feet on November 1, 1957, but postponed it until 1 December. The Navy and Air Force felt that they had too little time to put new rules into effect. At present, the Navy and Air Force are the main users of the upper air space, but the CAA also plans to assume traffic control of commercial jets.

PUBLICATION NEWS Interscience Publishers, Inc., has recently taken over the distribution of the publications of the Microwave Research Institute of Brooklyn Polytech. A listing of the books available may be obtained by writing to 250 Fifth Avenue, N.Y. 1, N.Y. These publications include the Symposia Series, edited by Jerome Fox, as well as the Handbooks of Microwave and Electronic Measurements.

CALLING ALL "HAMS" The annual Single Sideband Dinner will be held during the IRE Convention, Tuesday, March 25, 1958 at the Hotel New Yorker. Tickets are $7.50 each and can be obtained from: The Single Sideband Amateur Radio Assn., Inc.—267 Madison Avenue—New York 16, New York.

THE FOURTH NATIONAL SYMPOSIUM ON RELIABILITY AND QUALITY CONTROL will be held January 6, 7 and 8, 1958, at the Hotel Statler in Washington, D.C. Some 50 outstanding authorities in the field of quality control and reliability will present a "Report to the Nation" on the progress in reliability, covering fields of reliability in the electronics industry. The symposium is sponsored by IRE.

Value Engineering

(*Continued from page* 27)

Operations. The technical bureau develops equipment and systems to meet these requirements. Close coordination must be maintained to insure that the requirement is realistic and economically feasible of accomplishment, and that the development is proceeding toward the desired goal.

Second—between the bureau and the contractor. Here also close coordination must be maintained to insure that the equipment specification is realistic and feasible of accomplishment without excess cost, and that the work, whether design, development or production, is proceeding toward the desired goal and toward the scheduled delivery date.

Benefits

In my opinion, one of the primary benefits that may come from this program is that a contractor will be encouraged to question a provision of a bureau specification that may appear unrealistic, unnecessary or excessively costly. In turn, the bureau should feel encouraged to use the communication line to Office of the Chief of Naval Operations to question an unrealistic or super-expensive provision in a requirement or development characteristic. I think it will be found that some of the provisions may not be as sacred as they may have seemed in the past.

One other aspect I would like to mention, since it is particularly pertinent in my own field, communications. The communications problem of the military services is not unlike that in the commercial communications field in many respects. Therefore, whenever it is practicable to do so, it makes sense and is good value engineering for us to adapt our operational requirements to existing commercial designs or production. In so doing, we save money and we get a good commercially tested and approved product, with readily available spare parts. This concept is not only applicable in point-to-point communications (where our equipment and problems are very similar to those of commercial communications), but also, to some degree, even to the more difficult area of shipboard communications. For example, in order to attain a capability that could be met in time in no other way, the Navy recently bought a quantity of commercial off-the-shelf communications equipment. While this equipment does not fully meet military standards, it has performed surprisingly well, with reasonable reliability, and it is relatively inexpensive. The highly competitive commercial communications field is a good proving ground for this kind of equipment, both for performance and dollar value.

Disseminating Information

Value engineering is a relatively new factor in Navy-industry relations. It is imperative, therefore, that more and more information on value engineering be disseminated so that the Navy and industry, together, may benefit from its many applications through better understanding of the Navy's goals.

Looking Forward to the Future

(*Continued from page* 20)

The data link subsystem consists of the various means of communications used in transmitting instantaneously, to a central station, the information collected by devices in manned or unmanned (drone) aircraft from distances equivalent to the ranges of our modern weapons.

The processing subsystem will employ automatic data processing equipment, tailored to fit evaluation, collation and storage requirements at all military echelons, Field Army to battle group.

The display subsystem is that portion of the surveillance system used to display to the commander and his staff useable information or intelligence in an effective manner commensurate with the requirements at his headquarters.

A very important portion of combat surveillance functions is target acquisition. Research and development continues to be active in this field to improve the target acquisition and location capability to enable modern weapons of the LaCrosse, Honest John, Corporal, Sergeant and Redstone class to fire upon a target with first round hit or kill and to the limit of their ranges under all weather and visual conditions.

STOCKPILE issue

STOCKPILE

Never in the history of our country have the "5 Big M's"—Money, Man power, Materials, Manufacturing and Management—in national security and their interrelationship with the military, psychological, economic and educational factors been as important as they are today. The stockpiling of this information among other information in the communications and electronics field is indicative of the objectives of the Armed Forces Communications and Electronics Association. This is the background and the thinking behind SIGNAL's special "Stockpile Issue" coming in January, 1958—a publication which should interest everyone.

THE EDITOR

BY LEE LEVITT

Engelhard Industries

Milton M. Waller,
Military Services
Division Head

APPLYING THE FACILITIES AND skills of a widely diversified group of metals and electrical manufacturing firms to military research and development is the complex task of Engelhard Industries' newly formed Military Service Division, headed by Milton M. Waller.

Headquartered in Newark, N. J., Engelhard Industries has ten manufacturing subsidiaries in the United States—Baker & Co., D. E. Makepeace Co., The American Platinum Works, The H. A. Wilson Company, Hanovia Chemical & Mfg. Co., Amersil Co., Irvington Smelting & Refining Works, National Electric Instrument Co., Azoplate Inc. and Charles Engelhard, Inc. It also has a substantial interest in Nuclear Corporation of America and extensive operations in Canada and overseas.

These firms design and manufacture a wide range of precision equipment with military applications—ammeters, transformers, galvanometers, anemometers, electrical contact subassemblies, timers, ultraviolet meters, ignitors, mechanical fuses, cathodic anti-corrosion systems for ships, boiler level gauges, crystal mixers, duplexers, waveguides, quartz cavities and delay lines, gas-discharge lamps of many kinds, thermocouples, resistance thermometers, optical devices, gas analysis systems, gas generators and purifiers, antennas, rupture discs, spinnerettes, and uranium-reactor components, radioactive isotopes and many other items.

In addition, they produce such basic materials as metal strip, tubing, wire, clad and laminated metals, brazing alloys and fluxes, electrical contact materials, thermostatic bimetal, constant-modulus alloys, chemical catalysts and optically clear quartz.

Offhand, it might appear relatively simple to steer an industrial organization with these capabilities into the main stream of military research and development. It is not quite that easy, however, according to Mr Waller.

"To begin with, the fundamental philosophy of military research is different," he says. "The Armed Forces do not take the 'marketing' approach our people are accustomed to encountering in straight commercial sales. The emphasis is on stringent specifications, foolproof operation under every conceivable condition, and ease of maintenance, rather than upon potential markets and end price."

He hastens to explain that he has found the Federal Government and its prime contractors to be quite cost-conscious, but in a different way from private companies.

"In straight commercial operations, cost is not only important, but often utterly controlling—no matter how good it is, the product may be unable to find a market if it passes out of a certain cost bracket. In other words, the aim is to produce as good a product as possible within a certain cost. In most military contracts, however, the aim is to develop as cheaply as possible a product which meets certain inflexible specifications. The difference between the two approaches is slight in some cases, but in others it is of great practical importance."

He points out that some companies — notably those closely connected with the aircraft industry—grew up on military contracts, so that their engineers are imbued with the spirit of military research. "Most of the Engelhard companies, however, reached maturity long before World War II, and, although they have handled many Government contracts over the past 20 years, they have never devoted themselves primarily to work of this kind. Thus, there is definite need for a coordinating agency between them and the Armed Forces."

The sales staffs of the various companies handle by themselves all Government contracts for more or less standard items. The Military Service Division handles only those jobs "where there is no product as yet—in which the whole idea is to come up with something new. If, after research and development, the item becomes standard, the Division drops out of the picture."

One of Mr. Waller's problems is the very diversity of the Engelhard family, and the fact that the companies' operations overlap to a certain extent. His office must decide which company should handle what project. Sometimes the job is split between several of them.

Once the Military Service Division has the details on a proposed contract, it helps the chosen Engelhard company or companies develop a detailed proposal, and submits this through the proper governmental channels. After the contract is awarded, the Division handles all paper work and coordinates all communication between Engelhard scientists and the procuring agency. On "crash" jobs, it helps secure letters of intent or other documents which will speed things up. Thus, the military agency and/or major contractor does not have to deal with salesmen or engineers who do not understand their procedures and problems, and Engelhard research personnel are freed of responsibility for negotiation.

Since the Division was set up 18 months ago, it has secured and managed some 400 projects. Many were direct contracts with the Armed Forces. Others were subcontracts from such companies as General Electric, Sperry, Western Electric, Convair and Eastman Kodak.

A mechanical engineer with a Master's Degree in Industrial Engineering, Mr. Waller has served with various Engelhard companies for 15 years. At one time, he headed the Instrument Division of Baker & Co. He coordinated Engelhard's military contract work on an impromptu basis for several years before the Division was set up officially.

The Division now has offices in Newark, Washington, Dayton and Boston. The Newark office handles most of the subcontracts. The Boston office works with the Air Force's Rome (N.Y.) and Cambridge (Mass.) Air Development Centers, and the Dayton office with the Wright ADC. The Washington office handles work

(Continued on page 47)

Army Requirements in Basic and Applied Electronic Research

by Dr. H. J. Merrill, U.S. Army Signal Engineering Laboratories, Fort Monmouth, N.J.

THE ARMY SIGNAL CORPS HAS enjoyed a long and profitable association with the commercial world since the inception of the modern Corps at the dawn of the electronic age. In many cases, its activity has been the ferment that has contributed to our country's electronic growth. In an attempt to maintain contact in the expanding economic horizons of our world, it has been necessary to accelerate the development of communications. We point with justifiable pride to the Signal Corps' role in the development of wire telegraph, radio, meteorological systems, aviation, radar, computer techniques, and the "Missile Master," all of which have contributed to the growth patterns of industry.

The association of commercial interests with the Department of Defense, assisted greatly by the pressure of forceful military leaders, is the most responsible factor in the acceptance of the research philosophy and the prosecution of a large relative effort in research and development. This acceptance of the application of research has made possible the recent industrial expansion of our country. A new industrial revolution, much more drastic than the old one and loaded with implications of a vast changing world, has taken place since the beginning of the Korean War in June 1950. Our horizons have expanded at an accelerated pace due to the generous application of research to everyday problems. It is a change which may be described scientifically as a change in research methods. We now have access to electronic computers which permit the solution of problems unhampered by the setting of limitations in the boundary conditions which we formerly needed in order to perform the mathematical processes. This in itself explains our ability to extend our research many orders of magnitude beyond standard conditions. We become scientific explorers in a vast new area beyond our standard environment. The new industrial revolution represents a substantial effort in research and great initial foresightedness in its application to our problems.

Revolution in Army Adaptations

The Signal Corps is a technical service for the Army, which is the user or recipient of the military research. The Army is also going through a revolution. All students of tactics and strategy see the vital importance of the right sort of an Army in any future conflict. To be effective in this industrial age, the Army has to develop new concepts and new organizations in which an army unit has the capability for sustained combat air transportability and battlefield mobility. According to the *Army Information Digest*, the new Army must be based on these four principles: First, adaptability to the requirements of the atomic battlefield; second, utilization of equipment at the higher echelon; third, recognition of increased span of control, which is possible through modern signal communications, and fourth, adaptation to the new and better material as it is developed.

The Army's future battle area will have a greater breadth and depth and the units will be dispersed in smaller groups to avoid presenting large targets to enemy atomic weapons. The application of personnel will be drastically changed to fit the technological changes. Since fire power has increased out of proporation with other capabilities, more effort will be applied to mobility and communication. Although the number of combat troops will be greatly reduced, the Signal Unit, along with other support troops, will be enlarged. Upon examination of the four principles mentioned before, the importance of electronics and communications is apparent. They are prime factors in each of the four principles. Implementation of the new Army presents a great challenge in providing the surveillance, the communications and information for the tactical and strategic disposition of the units.

These then are the specific problems of the electronic requirements in the Army which are primarily in the areas of communication and control. Since a communication or control system always requires some type of intelligence as an input, the electronic problem is closely allied with other problems of accomplishing the mission of the Army. In this age, the input and output systems are primarily interested in electronic techniques. It should be borne in mind that there are forms of intelligence other than voice communication which now affect the communication load and spectrum. We are faced with the dilemma that wire transmission is fixed and difficult to maintain, but at the same time radio presents difficulties in the problems of interference and propagation.

Keystone to Increased Capacity

Basic research coupled with imagination are needed to develop new communications. We cannot achieve them by a routine exploitation of existing techniques. New reliability must be provided in order to link mobile units. Greater communication capacity must be provided for the additional intelligence load. Applied research is required to develop antennas that will be less bulky and will transmit in narrower beams. Also, applied research is needed to use better the modes of propagation that have been established.

The new mobile Army must see beyond the horizon because the centers of the Army units will be dispersed in depth. The Army must maintain an electronic surveillance by inspecting the surrounding area for enemy movements and must maintain control of a large area from these localized centers. The development of area weapons has now progressed to the point that weapon control of great areas is possible. Unfortunately, surveillance control has not kept pace with this development. Again, considerable imagination must be expressed in our basic research and brand new surveillance techniques must be devised. The problem of maintaining surveillance control is complicated by the necessity of developing location devices which will be capable of recognizing and identifying the target at the same time. Most conventional surveillance devices require line-of-sight. However, in the new Army, we have the necessity of extending our horizons far beyond line-of-sight. This is a challenging problem.

In the establishment of new basic research and especially in applied research, the keystone often becomes the development of new components and devices. A considerable effort, therefore, is required to maintain the research and development of new components and devices. Actually, the military has sponsored much of the tremendous effort devoted to components and interest in this field is increasing daily. Although the development of solid-state devices such as transistors, which are useable at higher frequencies and temperatures, is actively sponsored, further extensions must be accomplished. The activities in nuclear and atomic resonance in the development of the MASER (Microwave Amplification by Stimulated Emission of Radiation) give promise of new communication techniques, although I am sure that we cannot predict at the present time just what turn these developments will take. It is certainly a rich field, a product of basic research which, in the next five to ten years, will have most gratifying applications. In connection with the electromagnetic spectrum, the laboratories also have an interest in the development of detectors in the radiac field, and possibly some applications of gamma radiation and neutron energy may be applied to our communication and surveillance problems.

The complex and far-reaching supply lines of the modern Army require that logistic information be made available from the factory to the supply services to the combat unit. The problem of supplying replacement parts and expendable supplies has always been extremely difficult to solve under combat conditions. To cite an example, in World War II, we had considerable complaints from the field to the effect that replacement supplies were not available for our sound ranging equipment. This was surprising because we had shipped great quantities overseas. Finally, we sent an engineer over to trace these supplies. He finally reached a point in the Netherlands where, according to the records, the supplies were stored. He queried the harried Supply Officer who said, yes, he had them, then took our engineer out to a pile of boxes 100 feet high, 100 yards wide and a mile long and said, "They are in there." As you may well imagine, the loading of such supply pipe lines becomes very expensive and to make it worse, does not fulfill its function. With the development of modern comunications and transportation and the application of new electronic data processing systems, we look forward in our applied research to eliminating static supply depots and cutting down on the quantity of depots required, thereby making the supplies more rapidly available.

Man Power, Mobility and Money

We are interested in computer activities as a great assistance and saver of man power in our basic and applied research activities. We are also looking forward to the development of special purpose computers for solving our surveillance and communication problems. As the trend in the growth of electronic instrumentation increases, and as the electromagnetic spectrum is more fully utilized, the problems of electromagnetic space become magnified, the problem of reliability is increased, and the ability to take countermeasures against the system increases. Our interest in countermeasures and counter-countermeasures is easily recognized. With the expansion of electronic technology in other countries, the problem takes on increased seriousness.

The Signal Corps, both in its internal program and through external contracts, has had a long-term interest in meteorological instrumentation. Although cognizant long-range meteorological forecasts reside with the Air Force, the effects of meteorological conditions become more important insofar as they affect Army mobility, surveillance, and long-range fire power.

There is an increasing requirement to establish a local area forecasting ability and a better understanding of the local effect due to mass meteorological movements. In establishing the use of meteorological data, it becomes apparent that a knowledge of the mass meteorological conditions is more important than a single local meteorological measurement. There is an increasing awareness of the effect of mass effects so that true meteorological corrections can be made for local fire control purposes. There is great opportunity to establish meteorological measurements by using ground-based instruments rather than by sending up sounding instruments into the atmosphere by balloons or rockets. For instance, a radar study of the ionospheric motion may be related to the weather by using the results thereof to determine the position of weather fronts and to determine the mass weather effects.

Considering the principles of the new Army and the areas of responsibility of the Signal Corps, we may develop the objectives of the future basic and applied research, although we should not speak too finely of an objective with respect to basic research.

One of the first considerations and one of the most troublesome problems is the saving of man power. Studies have proved that the man with the high IQ makes the best combat soldier. Unfortunately, this is practically an impossible situation for there are not enough high IQ men to go around. Our ultimate objective is to furnish equipment which saves this man power. Obviously, it is not satisfactory to have equipment which replaces one soldier if it takes one engineer to keep it operating.

The next requirement is to provide instruments that will perform functions for which there is nothing available at the present time. We need to extend the spectrum of time and space for each area of interest of the battlefield in the expanded concept. One of the most neglected things in the Army has been mobility. We need to be able to move our combat troops quickly, and to know where they are and what they are doing. While the movement of the troops is not an electronic responsibility, it is the big responsibility of electronics and of communications, to know where the combat units are, what they are doing, and to see that they get the required support. In recent maneuvers that I attended, in which large

numbers of tanks were employed, it became quite apparent that we are going to have insoluble difficulties with that old reliable telephone line, for tanks are very efficient wire collectors. They can wind miles on their treads with no effort at all.

Finally, there is the economic problem which is also of great importance commercially, that is, electronic equipment must make things cheaper. It must be more efficient and save at all points in the supply line, in production, and in material and labor costs. General Gavin, our Chief of Research and Development in the Army, in describing basic and applied research, stated: "A majority of work is executed by contract with industry, universities, and non-profit organizations. A lesser portion of the research and development effort is performed within Army laboratories in order to maintain the level of competence for effective quality control of contracts, and to carry out such functions as requirements formulation, development planning, feasibility determination, testing, and evaluation." Under this charter from our Chief, I would like to comment that research and development at the present time is not efficient, and costs are too high. Defense industry must accept its part of the responsibility for the national budget. Although there are many responsible contractors, there are also those who do not appear to accept contractual commitments seriously. Many of the proposals and activities submitted for approval are repetitive and inconsequential. Often, when in the course of a contract it appears that nothing of consequence will develop, it becomes unduly costly to get an agreement to terminate the activity.

Avenues to Avoid

For a long time the Signal Corps was a salient for the use of fixed-price contracts in the Government. Because of defects in the fixed-price instrument, cost-plus-fixed-fee contracts have been written. However, it appears that we have jumped from the fire. In the first place, many of the bids received do not even come close to representing the final cost of the contract. It is embarrassing for a unit in our laboratory with a three billion dollar budget to receive a three-quarter million dollar over-run on a one-quarter million dollar contract. (This actually happened.) The other defect is the almost universal failure to meet specified contractual delivery dates. Although the cost-plus-fixed-fee contract allows greater contract flexibility, it does not have the right kind of incentive. It would be better to have a positive incentive, which pays a bonus for superior performance, instead of the negative incentive which allows a poor performance to continue indefinitely.

Those of us old enough to remember back before the Korean War may recall that the country developed a surplus of engineers because of a cutback in research effort. This must not happen again. Since basic research is very long term, we should profit by history's example and plan for the future; we cannot let the effort lag or fluctuate. Some method of funding must be found whether it is from the Federal budget or otherwise. Research funded directly by the Federal Government has found application in all facets of industrial production; our economy has been reaping the benefits of the research and development program. The profits have been most gratifying not only in their military application but also in the innumerable applications of the research to our everyday living.

With the above statement of requirements and needs, it will probably interest you to learn the methods by which the programs of basic and applied research are carried out. The Signal Corps maintains a small internal basic research program in which investigations are made to acquaint our personnel with new developments in the field, and to contribute as much to that field as our capabilities will allow. The Signal Corps also carries on an internal applied research program largely for the same purpose. The laboratories have also served as a crash facility and have participated in newly established investigation efforts in connection with such things as the atomic bomb, guided missile activity, Arctic propagation and meteorological research. It has participated on a crash basis in various Army maneuvers in which an attempt was made to establish requirements by demonstrating in the field new techniques which may be applicable to the Army problem.

One of the most rewarding activities with respect to basic research has been participation with the Air Force and the Navy in joint research contracts placed largely with universities. The extension of these joint contracts to other organizations has been taking place recently.

Most of the basic research and much applied research is carried out with commercial concerns. Contracts are often placed initially on a competitive basis, although it is difficult to establish a real competitive situation on the basis of a loosely drawn specification, as is usually the case with research specifications. On a competitive bid, an attempt is made to evaluate the quality and amount of manpower applied to the immediate problem under consideration.

The problem of fulfilling the objectives which have been outlined requires the application of energy and imagination. Too many contracts which have been labeled "Study" are carried out where one tends to forget that study is the tool of research, not the end. The end of basic research is invention, classification and exploration. We are getting too many tools and not enough end-production invention. The basic research is a long-term proposition which finally is the only instrument that will lead to the solution of our problems. If we don't apply continuity of effort to the long term problems, we will find our energy dissipated in a series of interim steps in which the advance from step to step is not significant. The fundamental factors that make for research growth are the thoughts and the ideas. In the words of Schiller, "It is the spirit itself which fills the body."

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POMSEE Puts Them To Work

by J. R. Jackson, RCA Service Co., Inc.

THE NAVY, LIKE OTHER MILITARY Services, is faced with the modern-day maintenance problem resulting from complex equipment and the need for correspondingly longer training schedules. The percentage of time that must be spent in training to attain maintenance proficiency on any electronic equipment is high. Therefore, only a short time remains during an enlistment when a man's services can be used operationally.

A simplified maintenance plan for shipboard electronics equipment is being used successfully by the Bureau of Ships. The POMSEE program (Performance, Operation, and Maintenance Standards for Electronics Equipment) has been developed and evaluated as an answer to the maintenance problem.

The Basic Plan

Since a large percentage of maintenance man-hours is spent in checking and testing electronics equipment, the use of relatively unskilled personnel for this work seems logical. Thus, a greater percentage of the time of experienced personnel could be released for troubleshooting, critical adjustment, and the final setting up after repair. Also, with more time available, the experienced engineer could work more efficiently.

POMSEE enables relatively untrained personnel to be utilized by setting up Performance Standard Sheets and Maintenance Standards Manuals for each equipment. It also enables engineering personnel to make checks at any time to determine if the equipment is operating as it should. It also sets up a series of preventive maintenance routines to be carried out at periodic intervals to assure continued normal operation of the equipment. POMSEE material encompasses for each equipment a Performance Standard Sheet, and a Maintenance Standards Book (Part I, test procedures and maintenance references; Part II, preventive maintenance check-off).

In essence, the maintenance thinking is done by engineers who are familiar with maintenance procedures and with particular equipments. The results of their efforts are set down in chart and picture form. Personnel unfamiliar with the particular equipment can nevertheless carry out much of the testing that is required, using this information.

Performance Standard Sheet

The purpose of the Performance Standard Sheet is to indicate the equipment's expected operational capability. This is accomplished by taking a specific series of technical measurements contained in the Maintenance Standards Book, Part I, the results of which may be used for reference when determining the condition of the equipment during future tests.

These tests and measurements are made at significant points of the equipment. The tests are grouped according to functional sections—that is, all the electrical circuits and mechanical parts that act together to perform a specific function, such as transmitting, receiving, and so forth.

Maintenance Standards — Part I

This section establishes a series of maintenance standards tests that can be recorded in simple tabular form. Starting with the simplest basic test, such as checking the input voltage, it includes a progressive series of tests in logical sequence covering the entire equipment.

On the test chart, the first of five columns shows the "step" or test number. The second column, headed "Action Required," states briefly the purpose of the test. The third column, "Preliminary Action," states how to set up the test: "Connect multimeter to terminals 1 and 3 of T101." The fourth column is headed "Read Indication On," which is self-explanatory.

The last column, "Maintenance Standard," provides space for recording the actual reading. Limits for guidance are listed for each reading.

On the page opposite the test chart in the Maintenance Standards Book, Part I, is a line drawing of the equipment or unit with call-outs numbered for each "step" or test number of the chart. The test equipment is shown connected just as described in the test chart, or the controls or meters of the basic equipment itself are indicated when described in the chart.

When the illustration does not show the exact connections clearly, blow-ups of the area in the chasis are shown so that full visual understanding is possible.

Maintenance Standards—Part II

The purpose of the second section of the Maintenance Standards Manual is to provide maintenance personnel with systematic and efficient preventive maintenance instructions for a specific equipment. The format is similar to Part I.

Steps are included or references are made to steps contained in Maintenance Standards, Part I, for periodic accomplishment and are designated as routine or technical. Routine steps are identified on the applicable page. To lighten the load of the technician, the routine steps may be performed by operating personnel.

Usually, the first step in Part II is the daily routine of placing the equipment in full operation. Next is a series of weekly checks including certain maintenance standard checks, followed by adjustments, inspection and cleaning operations.

The monthly routine usually includes complete inspection for mechanical faults, cleaning and tightening of insulators and bushings, cleaning of chassis and so forth.

The quarterly checks include, in the case of a receiver for example, such items as testing sensitivity and bandwidths of the various circuits, checking signal-to-noise ratio, adjusting wave traps and checking circuit alignment.

Following each series of tests in the manual—daily, weekly, monthly, quarterly—is a date chart covering a period of 2 years. Pertinent readings and the initials of the person making the tests are to be entered in these charts.

Use of Manuals and Sheets

Performance standard measurements are accomplished in the field for an individual equipment upon receipt of the Performance Standard Sheet and Maintenance Standards, Part I. After equipment overhaul or after accomplishment of major field changes, these measurements are again made.

After an over-all checking and peaking of sections, the prescribed tests and measurements of the Performance Standard Sheet are made and the results entered in the spaces provided in the Maintenance Standards, Part I. The technician follows up with his portion—the remainder of the Part I measurements and the preventive maintenance instructions of Part II.

POMSEE thus provides a logical series of test procedures that can be carried out by electronics personnel not necessarily experienced in the particular equipment involved. It does not attempt to get into the why, what or how of corrective maintenance since these subjects are already covered by the technical manuals and other publications.

POMSEE does provide the indications of normal operation capability and shows the functional section involved when abnormal operation is present. It provides the simplified steps necessary to assure continued normal operation. If the records show that readings for a particular step vary progressively in the same direction every time a check is made, there is a definite indication of improper operation, and corrective measures must be taken.

POMSEE manuals and sheets have been, are being, or will be prepared under contract for most of the electronic equipment under cognizance of the Bureau of Ships. As new equipment procurements are made, POMSEE manuals and performance standard sheets will be prepared simultaneously.

Based on past performance, POMSEE is assured of continued success in the Fleet.

AFCEA Group Members

Communications—Electronics—Photography

Listed below are the firms who are group members of the Armed Forces Communications and Electronics Association. By their membership they indicate their readiness for their share in industry's part in national security. Each firm nominates several of its key employees or officials for individual membership in AFCEA, thus forming a group of the highest trained men in the electronics and photographic fields, available for advice and assistance to the armed services on research, development, manufacturing, procurement, and operation.

Admiral Corp.
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Allied Radio Corp.
American Cable & Radio Corp.
American Electronic Laboratories, Inc.
American Institute of Electrical Engineers
American Machine & Foundry Co.
American Radio Relay League
American Telephone & Telegraph Co.
American Telephone & Telegraph Co., Long Lines Dept.
Ampex Corp.
Amphenol Electronics Corp.
Anaconda Wire & Cable Co.
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Barker & Williamson, Inc.
Barry Controls, Inc.
Bell & Gossett Co.
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Bell Telephone Laboratories, Inc.
Bendix Radio Division, Bendix Aviation Corp.
Blackburn Electronic Corp.
Bliley Electric Co.
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Federal Telephone & Radio Co.
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Production Research Corp.
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Saxonburg Ceramics
Society of Motion Picture & Television Engineers
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Trad Electronics Corp.
Transitron Electronic Corp.
Triad Transformer Corp.
Tung-Sol Electric, Inc.
Union Carbide Corp.
United Telephone Co.
United Transformer Co.
Waterman Products Co., Inc.
Webster-Chicago Corp., Government Division
West Coast Telephone Co.
Western Electric Co., Inc.
Western Union Telegraph Co.
Westinghouse Electric Corp.
Weston Electrical Instrument Corp.
Wheelock Signals, Inc.
Wickes Engineering & Construction Co.
Wilcox Electric Co., Inc.
Willard Storage Battery Div., Electric Storage Battery Co.
Wisconsin Telephone Co.
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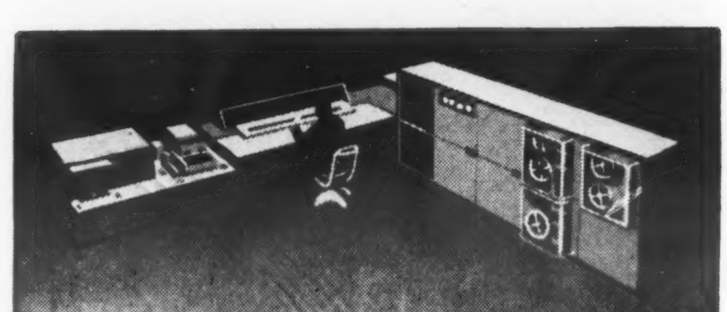

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Chapter News

Arizona

The chapter's annual elections were held in September with Arthur H. Mudgett, Chief Technical Planner, USAEPG, re-elected president.

The other officers were named as follows: vice president—Lt. Col. Leonard F. Walker, Technical Operations, USAEPG; secretary-treasurer — Dr. James C. Coe, Chief Engineer, Science Division, USAEPG; directors—Col. Edmund T. Bullock, Deputy Commanding Officer for Technical Program, USAEPG; William S. Marks, Jr., Chief Scientist, USAEPG; Forrest G. Hogg, USAEPG Resident Representative for Motorola, Inc.; William W. Lord, Manager, Tucson Office, Defense Products Group, American Machine & Foundry Company.

Augusta-Fort Gordon—Shown during the October meeting are, left to right: C David P. Gibbs, USA Signal Training Center, Ft. Gordon; Col. Braxton E. Small, chapt president; Joseph S. Siegel, Vice President and General Manager, for Georgia, of Southe Bell Tel. and Tel. Co.; Charles M. Eberhart, General Commercial Manager, Southern B Tel. and Tel. Co.; Col. Erling J. Foss, Chief of Staff, USA Signal Training Center, and Ho Gibson, Augusta District Manager, Southern Bell Tel. and Tel. Co.

Augusta-Fort Gordon

Mr. John S. Siegel, Vice President and General Manager for Georgia, of the Southern Bell Telephone and Telegraph Company, was the guest speaker at the October 17th meeting.

Stating that one of the basic precepts of the American way of life is the manner in which it has let business operate, "both through customs and laws." Mr. Siegel went on to point out that "when business becomes big, it is a sign of success—not a sign that big business is bad."

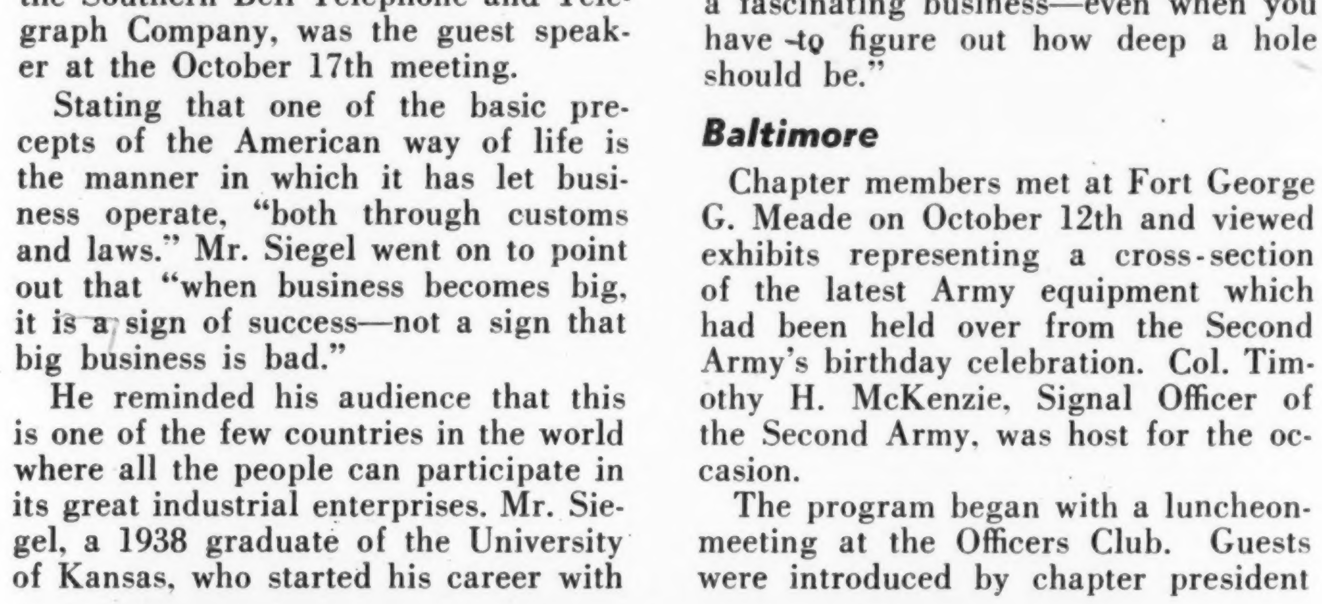
He reminded his audience that this is one of the few countries in the world where all the people can participate in its great industrial enterprises. Mr. Siegel, a 1938 graduate of the University of Kansas, who started his career with the Bell system by digging post holes, brought a chuckle from his audience when he remarked that "telephony is a fascinating business—even when you have to figure out how deep a hole should be."

Baltimore

Chapter members met at Fort George G. Meade on October 12th and viewed exhibits representing a cross-section of the latest Army equipment which had been held over from the Second Army's birthday celebration. Col. Timothy H. McKenzie, Signal Officer of the Second Army, was host for the occasion.

The program began with a luncheon-meeting at the Officers Club. Guests were introduced by chapter president Henry B. Yarbrough as follows: Cap Wilfred B. Goulett, AFCEA Executi Vice President, and Mrs. Goulett; Cap William G. Shaffer; L. Harriss Robi son, president of the Washington chap ter; CWO James C. Hawley and Rol ert T. McArthur of the Bureau of Ship Department of the Navy; James Lon of Minneapolis, and James H. Kellog a former president of the Chicag chapter and now a member of the Ba timore chapter.

Among the items of interest in th Army equipment display were: hel copters ranging in size from th "Bubble" to a jeep carrier; mobil field television chain; calibration va —used to calibrate all field repai men's instruments; a display showin miniaturization of transformers, resis tors and capacitors; tactical VH equipment used at Army Corps level mobile photo laboratory; mobile tele type system. Also exhibited were mod els or mock-ups of five missiles—Littl John, Hawk, Hercules, Honest Joh and Corporal.

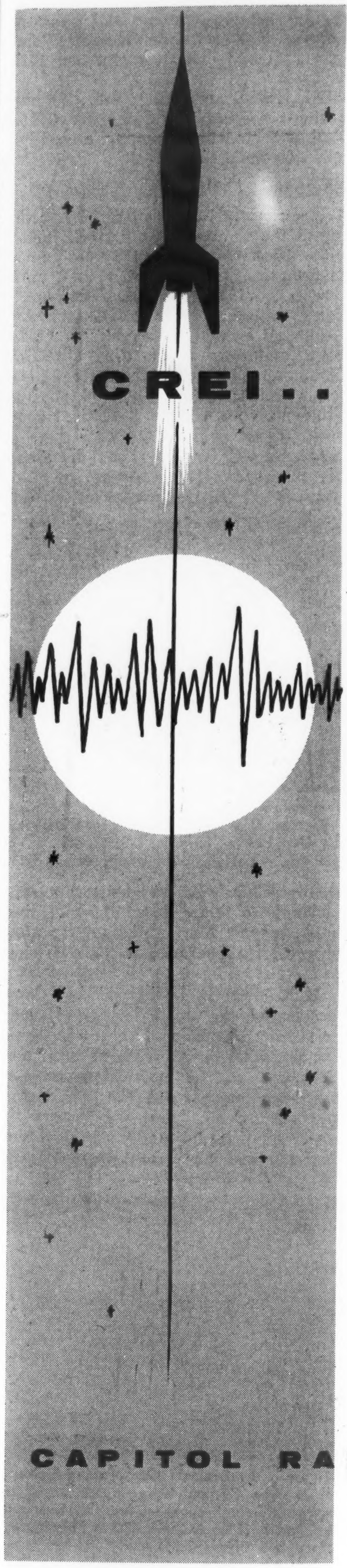


Baltimore—Pictured here are some of the chapter members and guests viewing the Hawk missile displayed at the October 12th meeting, held at Fort Meade. Mrs. John A. Shipley, recording secretary for the chapter, is credited with taking the photograph.

Chicago

The Kickoff Dinner for the 1957-5 chapter year was held on Septembe 26th at Hallicrafters Company, Chi cago. Preceding the annual dinner Hallicrafter's President and Chairma of the Board, William J. Halligan— former National President of AFCEA— hosted a cocktail party for the mor than 150 members and their guest who were present. Henry J. McDonald chapter president, presided over th business session.

With the applications of single side band suppressed carrier mode of trans mission being rapidly applied to hig frequency radio circuits, it was fitting that the main technical discussion o



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CREI courses are being studied *today* on the DEW Line and in the Antarctic—in Alamagordo and in Munich—by electronics experts in guided missile development and by telemetering technicians on the missile ranges.

How have we been able to keep pace? Because it has always been our aim never to deviate from our ideal: To provide the very best in technical electronic education for professional electronics personnel, regardless of the cost and effort required. We have spared no expense to keep our curricula and texts constantly expanding as the electronic world expands. Work is in progress right now on a new course for Atomic Reactor Technicians.

As we enter our 31st year, CREI has in effective operation, group training programs with organizations representing the cream—and including the vanguard—of the electronics and aeronautical industries. Our active student body includes 5,000 students in the Armed Services, in both enlisted ratings and commissioned ranks. Leading companies regularly visit CREI to select graduating students for the better-than-average technical jobs. Graduates of years back can be found in positions of great responsibility throughout industry and the military services.

We pledge ourselves to increasing effort, so that we may continue to warrant the confidence of the great industry whose every challenge it has been our privilege to meet.

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Fort Monmouth—Brig. Gen. Earle F. Cook, Commanding General, U.S. Army Signal Engineering Labs. at Ft. Monmouth, N.J. (center), is shown greeting Ralph O. Hutchison, American Machine and Foundry Company executive, who was the guest speaker at the October dinner-meeting of the chapter. Looking on is Halsey Hubbard, chapter president.

the evening was devoted to this subject. Fritz A. Franke, Manager of Communications Products for Hallicrafters, was the moderator of a panel composed of Peter P. Pichetto, U. S. Army Signal Communications Engineering Agency, Washington, D.C.; Edward A. Beane and Ralph H. Wickersham of the Electronic Supply Office, U.S. Navy, Great Lakes, Illinois.

Brig. Gen. H. F. Gregory, Commander of the U.S. Air Force Office of Scientific Research, Washington, D.C., was the featured speaker at the October 24th meeting, which was held at the offices and plant of Bell & Gossett Company, Morton Grove. William E. Peugh, Sales Manager of the Electronics Division, chairmanned the presentation of the Bell & Gossett story. Mr. Moore told the history of the company and described its products.

Oliver F. Johnson, Manager of Bell & Gossett's Electronics Division, introduced General Gregory, whose brilliant speech, "Exploratory Research in Electronics," stressed the importance of utilizing the latest discoveries of basic research as soon as possible. Examples such as the use of solid-state devices cryogenic circuits, and the MASER technique were cited. The complete text of General Gregory's talk will appear in a later issue.

London—Pictured at the September chapter meeting are, front row, left to right: Lt. Col. J. T. Tyler, USAF, chapter president; Maj. C. L. Bachtel, USA; Sir Reginal Payne-Gallwey, and Comdr. C. G. Mayer. Back row, left to right: Capt. H W. Gipple, USAF; Maj. F. E. Stant, USAF; Mr. L. T. Hinton; Col. J. A. Plihal, USAF; Mr. T. E. Goldup; Mr. A. E. Tyler

In the introductory speech, Mr. Johnson pointed out that General Gregory's office was responsible for the USAF rocket "Farside" which set an altitude record of 4,000 miles the day before the meeting. Mr. Johnson also related that General Gregory directed almost all of the USAF development leading to a practical helicopter. General Gregory is as well known in diplomatic circles as in scientific, having spent four years as Air Attaché in Paris.

Fort Monmouth

Ralph O. Hutchison, Assistant to the Vice President, Atomic Energy Division, American Machine and Foundry Company, addressed members and guests at the chapter's October 17th meeting.

Mr. Hutchison's talk, given after the business session and dinner in Gibbs Hall Officers Club, was on peacetime uses of atomic energy.

London

The chapter's September 24th meeting at the Columbia Club Hotel heard three guest speakers on diverse topics as follows: Colonel J. A. Plihal, until recently the Director of Communication-Electronics for the Tactical Air Command located at Langley Air Force Base, and now assigned as Director, Communications-Electronics, Headquarters Third Air Force, who spoke on the problems encountered in tactical communications.

Mr. John C. G. Gilbert next discussed his experiences as the master of ceremonies of the BBC television panel, "Inventors Club." He had many amusing incidents to relate, most of which had happened to him while interviewing people for appearance on his television program.

Major Bert E. Dowdy, USAF, Commander of the 303d Tactical Reconnaissance Squadron of the 66th Tactical Reconnaissance Wing at Sembach, Germany, was on tactical reconnaissance photography in the Air Force and covered in detail the history of aerial photography and its application to the Armed Forces requirement up to

(Continued on page 46)

New York—Pictured at the October 23rd meeting are, left to right: Walter Kirsch, Fairchild Camera and Instrument Corporation; Colonel M. A. Elkins, Commandant, Mitchell Air Force Base; Bill Madigan, President of Madigan Corporation, Brig. General Royal Hatch, Jr., Deputy to Lt. Gen. Hall, CONAC, Air National Guard, Mitchell Air Force Base; Major de Seversky, principal speaker for the evening; Ben Oliver, chapter president, Walter Watts, past National AFCEA President and an Executive Vice President of RCA; Admiral Fritz Furth, present AFCEA National President, and Captain Wilfred B. Goulett, AFCEA Executive Vice President.

the present date. He utilized visual aids and briefing charts to show various methods and types of aerial photography, assorted cameras equipped and how it is mounted in the aircraft, as well as the different types of pictures from different altitudes and positions.

New York

The chapter's October 23rd meeting heard an address on "Electronic Combat Power," by the noted aviation pioneer and inventor, Major Alexander P. de Seversky.

Prior to the meeting, held at the Belmont Plaza Hotel, members and guests assembled for cocktails and dinner. The guests at the head table introduced by chapter president B. H. Oliver, Jr., included Rear Admiral F. R. Furth, AFCEA National President; Capt. Wilfred B. Goulett, USN (Ret.), the new AFCEA Executive Vice President; Brig. Gen. Royal Hatch, Jr., Deputy for Air National Guard Affairs, and Col. M. A. Elkins, Commanding Officer of Mitchell Air Force Base.

Major de Seversky discussed the continued development of air power since World War II. He pointed out that nuclear weapons are getting more powerful and smaller, which serves to increase the fire power of the Armed Forces, but that the method of delivery will decide the issue rather than the type of weapons used. He stressed the supremacy of the Air Force in its mobility throughout the world.

The speaker defined air power as the ability to assert its will by air mobility and further said that air power is also space power, extending from the earth to infinity. In this concept, the control of the air is the control of space and, therefore, aircraft, missiles, rockets, etc., are interchangeable. Major de Seversky stated that, in his opinion, one Air Force instead of three military departments is essential to our national defense and that all efforts should be directed to increasing our electronics developments, including counter-measures against hostile air power and space missiles.

Rome Daily Sentinel

Rome-Utica — Dr. John R. Pierce, left, Bell Telephone Laboratories scientist, is shown conversing with, from his left: Maj. Clifton L. Nicholson, Assistant Chief of the Control Laboratory, Rome Air Development Center; E. Mark Wolf, Assistant Chief Engineer at Rome Cable Corp., and Fred W. May, Rome Sales Manager of General Cable Corp. Dr. Pierce discussed outer space travel at the October 16th meeting of the chapter.

Pittsburgh

On October 17th, chapter members were guests of Saxonburg Ceramics, manufacturers of precision ceramics. Chapter president George Adehold, who is General Manager of Saxonburg Ceramics, was host for the evening. The program included a conducted tour of the plant's facilities and a social hour.

An added feature of the meeting was a specially arranged tour of the nearby Carnegie Tech cyclotron installation at Saxonburg. Guides were provided to explain the operation of the atom smasher and to answer the numerous questions of the AFCEA group.

Rome-Utica

The chapter's October 16th meeting was reported in the Rome *Daily Sentinel* as follows: "A follow-up to discussion of travel in outer space at last night's meeting of the Rome-Utica Chapter, Armed Forces Communications and Electronics Association, is scheduled for January when the speaker will be Major David G. Simons.

"He is the Air Force officer who this summer soloed in a balloon at a record altitude of more than 100,000 feet—about 19 miles—and thereby, it is believed, proved it is safe for man to fly to outer space.

"Instructors and students, from Utica College, Rome and Utica high schools and the Mohawk Valley Technical Institute, were among the 265 persons present at last night's slide-illustrated lecture by Dr. John R. Pierce, Bell Telephone scientist, on the conceptions and misconceptions of the problems of space travel.

"His talk, given at the Griffiss AFB Officers Club, embraced the space tra-

vel of science fiction stories and the experiments of recent years in which mice and monkeys were sent 80 miles aloft, 'and when picked up seemed to be none the worse.'

"If the research animals can do it, continued Dr. Pierce, "men can presumably follow.' However, he cited the human form as the chief drawback. 'It is likely to be the weakest link in the chain' leading to space travel, indicated Dr. Pierce.

"He said, 'The human body is not adapted to conditions in a near vacuum.'

"Dr. Pierce, Director of Research for Electrical Communications at the Bell Telephone Laboratories, referred to the space travel problems anticipated by 'ingenious' science fiction authors—such hazards as those presented by meteors and cosmic rays, and how air pressure would swell an ill-designed space suit into helpless rigidity.

"He pointed out that while today it is possible to transmit a television signal to the moon, and even to the planet Mars, man's probing of nature and the consequent determining of laws of science have turned up additional space travel problems.

"Dr. Pierce said these laws reveal, among other things, that it is 'unbearably hot' inside the orbit of the planet Venus, and that space travel beyond the orbit of Mars is 'terribly hilly' as contrasted to smooth flight.

"His talk was supplemented by colored slides illustrating a voyage from the earth to the moon, Mars and to the planet Saturn."

Sacramento

A social get-together held at the MARS building, Sacramento Signal Depot, on September 30th, opened the chapter's activities for 1957-58. During an informal business session, members discussed program subjects for future meetings.

Guest speaker at the October 21st meeting was Dr. R. W. Gerdel, Chief of the Climatic and Environmental Research Branch of the U.S. Army, Snow, Ice and Perma-Frost Research Establishment, Wilmette, Illinois, who gave an informal lecture on military operations in the Arctic installations in the northernmost reaches of Canada. He also discussed "The City Built Under the Ice in Greenland" and related projects.

Dr. Gerdel augmented his discussion with a large collection of color projection slides.

The meeting was held at the Officers Mess of the Depot and was preceded by a cocktail hour.

San Juan

The September 26th meeting, held at Fort Brooke Officers' Club, was devoted to a discussion of how the chapter could assist the Commonwealth of Puerto Rico in initiating a ommend a positive program of chaptechnical training program in its vocational school system. Mr. A. L. Alicea of the Department of Education, present as a guest of the chapter, stated that the Commonwealth wished to institute a program of training for technical positions for communications and allied industries but that the Department of Education needed advice and assistance in initiating and conducting such a course.

The following committee was appointed to study the matter and recommend a positive program of chapter assistance: Eugene Klein, FCC, chairman pro tem; John Golden, RCA Communications, acting chairman; George Alich, CAA; Kinne Prachel, Prachel's TV Service; Jaime Acosta, Radiotelephone Communicators; and Gerard Lavergne, Puerto Rico Telephone Company.

Recommendations made by the committee were submitted to the October 24th chapter meeting and were approved for transmittal to the Commonwealth Department of Education. The principal recommendation concerned the shortage of qualified instructors to conduct the technical training. The chapter recommended a practical program of recruiting qualified instructors from the electronic industries and communications system in Puerto Rico. Another recommendation was that such training be aimed at obtaining a suitable FCC license at first, with options to change at a later date to telephone, telegraph or wire communications work.

Chapter President Wyman S. Borden announced his imminent transfer to Mexico City and tendered his resignation from office. He was given a unanimous vote of appreciation for his service to the chapter. Captain Gifford Grange, USN, Commanding Officer of the Naval Communication Station and vice president of the chapter, succeeded to the presidency. Mr. James P. Fitzwilliam, past president, was appointed to fill the vice-presidential vacancy.

Special guests at the October meeting were: Dr. Amador Cobas, radioisotope scientist at the University of Puerto Rico; Maj. Earl McCain, USAF, and six Air Force and Civil Air Patrol officers who were in Puerto Rico for the October 26th AF/CAP SARCAP, a fully-simulated search and rescue mission sponsored by the Air Force.

Tinker-Oklahoma City

The October 15th meeting was sponsored by the Southwestern Bell Telephone Company, with Clarence C. Flora of the engineering department, as the guest speaker.

Mr. Flora's subject was "Distant Early Warning Radar and Communications Projects in the Arctic." His presentation was illustrated by an outstanding collection of color slides and covered the early planning and logistics build-up for "Project DEW Line."

Included among the guests were members of the Oklahoma City chapter, American Institute of Electrical Engineers.

Washington

A complete progress report of the U.S. earth satellite program was given by Dr. Homer E. Newell, Jr., of the Naval Research Laboratory at the regular luncheon meeting on November 5th at the Willard Hotel. Total attendance was four hundred and fifty.

Dr. Newell is the Science Program Coordinator for PROJECT VANGUARD at the U.S. Naval Research Laboratory. He discussed various scientific uses of any earth satellite, and gave detailed information concerning the experiments to be performed with U.S. satellites as part of the International Geophysical Year.

Seated at the head table were: Dr. Newell; Hugh Odishaw, Executive Director, U.S. National Committee for the International Geophysical Year; Capt. Wilfred B. Goulett, AFCEA Executive Vice President, and the following chapter officials: L. Harriss Robinson of Motorola, president; vice presidents—Maj. Gen. Emil Lenzner, Deputy Chief Signal Officer; Brig. Gen. Bernard M. Wootton, Deputy Director, Communications-Electronics, USAF, and Ralph A. Irwin of Westinghouse Electric; secretary-treasurer — John R. O'Brien of Hoffman Laboratories; program chairman — John F. Gilbarte of Admiral Corporation.

Engelhard Industries

(Continued from page 33)

from Army, Navy and Coast Guard research agencies.

One of Mr. Waller's biggest problems has been that of securing qualified personnel. He says he has spent a year and a half looking for two men. "Our men work at the engineering level, so sales experience is not important; on the other hand, pure technical proficiency also is of little value. What we need are men capable of grasping the military veiwpoint and of working simultaneously in a number of highly technical fields. They must be able and willing to pick up a completely new subject every few months—constant study is required." He adds that it takes several years for even the most highly qualified man to become proficient in this work.

Present personnel of the Military Service Division, in addition to Mr. Waller, include T. W. Cushing, V. A. Forlenza, F. B. Baur and R. J. Smith.

INDEX TO ADVERTISERS

Why SIGNAL?

Here are several good reasons why SIGNAL would make the ideal Christmas gift. It affords chapter affiliation with friends in the electronics field. It creates a very congenial climate for the members of the civilian-military team to discuss and solve problems of mutual interest.

Secondly, SIGNAL Magazine is a continuing contact with the professions of communications, electronics and photography. It provides its readers with the best information on timely subjects and major developments of professional interest. It gives our advertisers a crystal clear shot to present facts about services, products and achievements to a specialized and interested audience.

Thirdly, the AFCEA Convention guarantees a highly intellectual and top side audience to hear presentations of technical papers on the latest in technical achievements and trends of the future. Members, guests and friends are given an opportunity to view first hand an entire display of products and/or services in an atmosphere of a masterfully coordinated technical trade show.

Lastly, of special interest will be SIGNAL's special January Stockpile issue, which will contain a reservoir of editorial content. It is an issue you will want to read.

SIGNAL's monthly magazine—12 important issues—makes the difference, when you want to know the facts of life in this electronic age.

The membership blank below is provided for your convenience.

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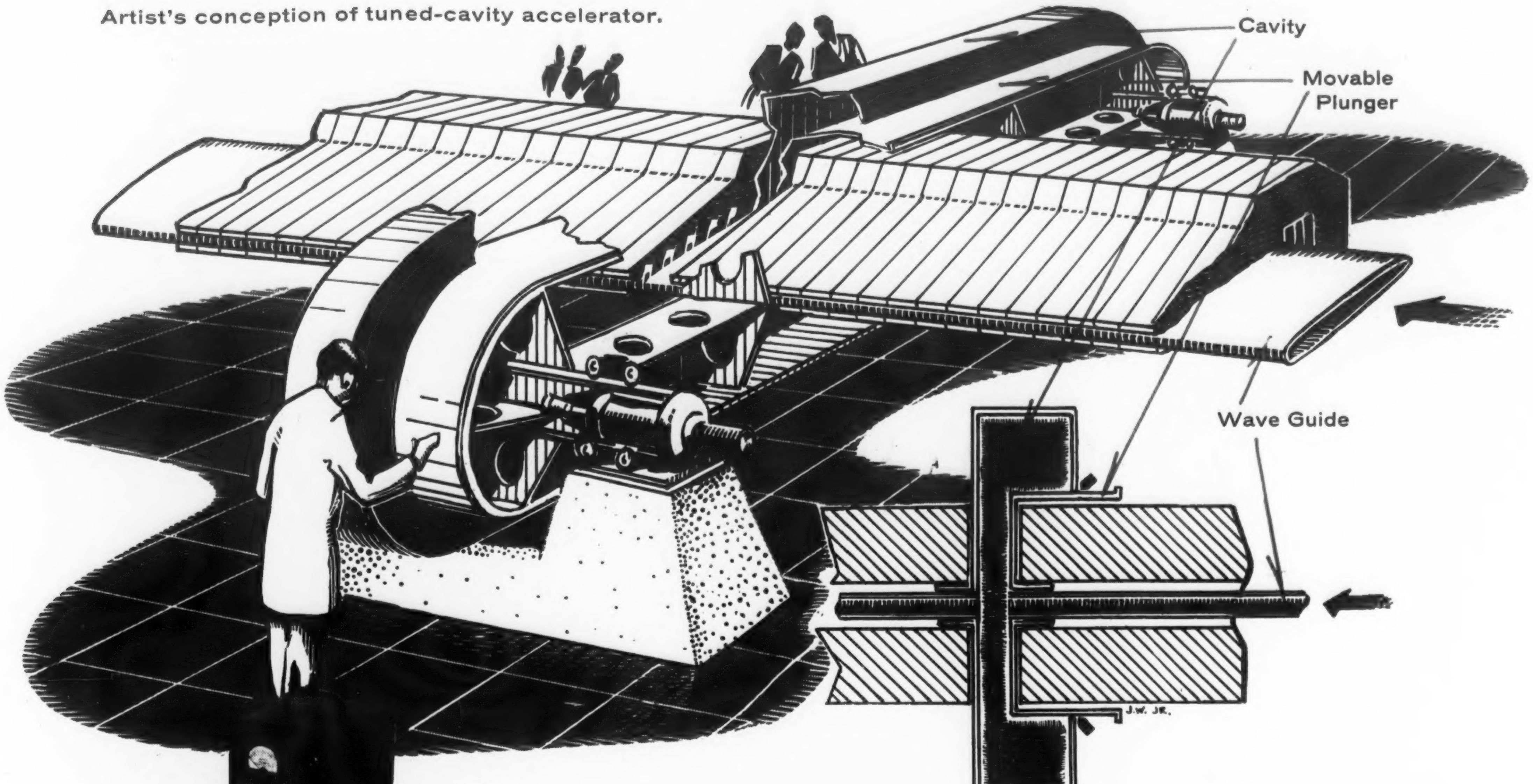
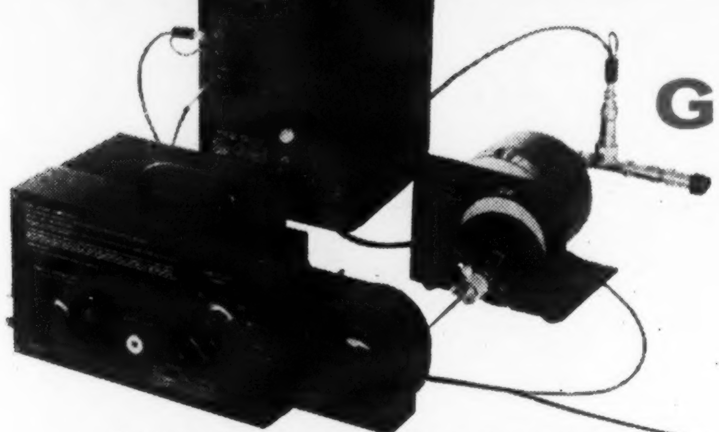
Artist's conception of tuned-cavity accelerator.





Setup used during accelerator development. Sweep Drive operates G-R Unit Oscillator while Type 1263-A Amplitude-Regulating Power Supply ($280) maintains constant oscillator output during sweeping. Constant output is obtained by comparing output signal with a reference voltage and applying a rapid correction voltage to oscillator plate supply.

G-R Sweep Drive Aids in Design of World's Largest Mechanically-Tuned Cavity

Research scientists at Iowa State College have developed a model of what will probably be the world's largest mechanically-tuned cavity. The cavity, designed for operation between 30 and 200 Mc, may serve as the r-f accelerator for a 15-25 billion electron-volt proton synchrotron. The cavity was designed under a project conducted by the Midwest Universities Research Association, a group of midwestern universities organized for the purpose of developing this new nuclear research device.

During development, the General Radio Sweep Drive proved indispensable for determining the effects of design changes in cavity models. The Sweep Drive was coupled to a G-R Unit Oscillator which excited the cavity over a broad frequency range. The cavity output signal was rectified and applied to an oscilloscope with a long-persistence screen. With this setup, cavity response could be panoramically displayed, making cavity resonances at various modes of oscillation clearly discernable and measurable.

Whether testing accelerators or amplifiers, the Sweep Drive cuts testing time without reducing accuracy. It extends the usefulness of manually-operated equipment such as oscillators, signal generators, receivers, and analyzers. It's a time-saver, labor-saver, and cost-saver all rolled-in-one.

G-R Type 1750-A Sweep Drive

Wide Range of Speeds — 0.5 to 5 cps, reciprocating motion.
Sweep Arc — adjustable from 30° to 300°.
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